



## The emergence of design practices in healthcare: designing prevention in medical simulation

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# Abstracts

## Learning from the past to shape a safer future

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# Plenary session 1

**Wednesday 01 October, 09.00–10.30**

Chair: Luise Vassie, IOSH, UK

Room: Carrick Suite

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Harry Shannon

McMaster University, Canada

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## **The place of evaluations in workplace safety: what can we really achieve?**

Many efforts to improve workplace safety are not evidence-based. Despite frequent calls for interventions to be evaluated, rigorous assessments are rare. Yet to make continued progress in improving safety, published evaluations are crucial. They allow decision-makers to understand what works and – just as important – what does not work in reducing injuries. As well, they may help us understand why ‘obvious’ solutions appear to be ineffective, distinguishing whether it is the solution itself or the way it is implemented that produces no improvement in safety.

Nevertheless, conducting good evaluations is not easy. There are several barriers, both methodological and practical. Companies, for example, that introduce safety measures may believe that the methods must work and, thus, not want to put resources into an evaluation; and, frequently, there will be a lack of expertise in the company to conduct an evaluation. Governments that introduce safety legislation, having expended political capital in a partisan debate, may likewise be reluctant to learn that their efforts have been in vain. Methodologically, difficulties include identifying a large enough sample size of workers or companies for a benefit to be detectable in a reasonable period of time, as well as the feasibility of applying strong research designs in workplaces.

I will describe various methods for conducting evaluations, noting their strengths and limitations, and briefly listing potential threats to validity inherent in each method. Methods include qualitative analyses, cohort studies, and randomised controlled trials (RCTs). I will note the difference between process and outcome measures, pointing out that the former may often be used as surrogates for the latter, to overcome the problem of lack of sample size, but I may beg the question about whether they truly reflect improved safety. Different approaches can be used in different circumstances, and it is important to distinguish the various levels at which interventions can be implemented. For example, interventions aimed at the individual can often be evaluated using RCTs, but this method may be impossible to use to understand the effect of policy and/or legislation.

The talk will describe examples of evaluations that have been successfully conducted, drawing lessons about when different methods can be applied. The question of how results from particular studies can be generalised will be discussed, taking into account factors such as type of industry, size of organisations, and local culture. Finally, I will consider prospects for improving the quantity and quality of workplace safety evaluations.

## Normal accidents, 1984-2014. Was Charles Perrow right for the wrong reason?

Charles Perrow's seminal book 'Normal Accidents', published in 1984, remains an important contribution in the field of technological risks, disasters and safety research. His thesis, that accidents in systems with a high level of coupling and complexity are inevitable, was released before a wave of major accidents across safety-critical systems in the 1980s. These included Bhopal (1984), Chernobyl (1986), Challenger (1986), Exxon Valdez (1987), Piper Alpha (1988), Port Edouard Heriot (1987), and Zeebrugge (1987). The timeliness of the book and its prescient and critical tone were, certainly, as crucial to its success as the quality of its content. Indeed, in a remarkable depth and breadth of investigation combining reports of accidents, news and scientific articles, as well as studies and books, the author managed, for the first time, to compare different systems (aviation, nuclear energy, transport, chemical industry) that had never before been compared. It helped to create, or maybe created, the category of high-risk organisations. The visual and graphical nature of his matrix that put these systems together, based on structural features in relation to their proneness to normal accident, helped make the thesis highly popular and easy to communicate. What should we think about this thesis, 30 years later, in 2014?

First, retrospectively, it appears that the rationale of the book has locked his author in a binary position between a technological determinism and a critical view of organisations. For Perrow, on the one hand, normal accidents happen because technology is, at times, so complex and coupled that nobody can anticipate these disasters; on the other hand, other accidents result from managers and corporations not trying hard enough, or being too powerful to be constrained (by regulators and/or civil society), in focusing on safety in their business decision-making processes. An interesting direction of the debates following the publication of the book in the last 30 years has consisted in revising this binary option by considering the uncertainties that surrounded accidents for the different categories of actors involved, including operators, engineers, managers, executives or regulators. As a result, a third option (whether a middle or alternative one) in Perrow's continuum of technological determinism and critical view of businesses has been established, which expands the unpredictability of accidents from a technological to a socio-technological view (Vaughan, 2005).

Second, following another wave of disasters across safety-critical systems, including nuclear (Fukushima), offshore (Macondo), spatial (Columbia), aviation (AF 447), petrochemical (Buncefield), chemical (Toulouse), and maritime (Costa Concordia), in a period of 10 years (Le Coze, 2013), one could argue, from an empirical and semantic point of view, that disasters have become normal – but not in Perrow's sense. They have become normal because their repetition has now created a sense of expectation, that, from time to time, a disaster will occur in high-risk systems. They, unfortunately, tend not to be surprising anymore. The paper will develop these two arguments and suggest framing Perrow's thesis alternatively: accidents are normal because, in an imperfect and uncertain world, they have kept, keep and will keep on happening, regardless of how much we want them not to. In that sense, Perrow was right; accidents are normal, but for the wrong reason. They are not unexpected products of technological determinism but products of a forever imperfect, globalised, complex and uncertain socio-technological world. Implications for safety research and practice are discussed.

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## Plenary session 2

**Wednesday 01 October, 11.00–12.30**

Chair: Luise Vassie, IOSH, UK

Room: Carrick Suite

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Kirsten Jørgensen

Technical University of Denmark (DTU), Denmark

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### Prevention of the many simple accidents which have major consequences

The European Commission and many European countries have set targets to reduce the number of serious accidents at work. The question is: what is meant by serious accidents, and what exactly is it that you have to reduce? Accidents are most often considered serious when leading to severe injuries for the victim. But the question remains: what risks have to be reduced? Conditions that we normally consider to be hazardous lead to much fewer serious accidents than simple, everyday conditions that we do not consider to be hazardous.

Major risks result in major consequences if accidents happen, and because of that, great effort is paid to manage major risks. We do not pay the same attention to simple, everyday conditions, where risk may be hard to observe, but where the majority of accidents happen. Despite a lot of rules and regulations, most enterprises fail to respond adequately to these trivial accidents.

The paradox of trivial accidents is that when the accident has happened, it is easy to see what went wrong, but because these trivial accidents only happen by accidental coincidence of many factors, it is very difficult to predict what, perhaps, may go wrong, and what the consequences will be.

Accidents are an important source of identifying risks, but a very poor measure of safety. Absence of accidents may be due to good safety, but it may also be sheer luck. We need a methodology to evaluate and predict safety before accidents happen, with the purpose of preventing those accidents.

An assessment of the presence of safety barriers can be an alternative to assess safety. The Dutch ORCA (Occupational Risk Calculator) project demonstrated that there is a statistical relationship between the presence of safety barriers and the occurrence of accidents, and also in simple situations when the safety barrier concept is understood broadly, i.e. to include both the physical safety barriers and the behavioural and managerial safety barriers. In this context, management, culture, skills, organisation and awareness are coupled with safety barriers. We claim that it is possible to observe safety barriers, in this broad sense, and thus that the presence of safety barriers, in relation to the conditions in which they are used, provide a proactive measure of safety.

The challenge is to identify the normative sets of safety barriers for the variety of different work conditions, i.e. the combinations of behaviour and physical safeguards that provide safety in the given condition. Doing things correctly and safely as a professional is identical to applying the correct set of safety barriers and the correct set of conditions, including management, culture, prioritisation, risk awareness, skills, etc.

Measuring the presence of safety barriers and the related conditions can become a leading indicator for the safety level, independent of the number and severity of accidents. How to do so will be presented in this paper and presentation.

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**Paul Haxell**

Bovis Homes Limited, UK

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## **When two worlds collide**

Research has a value, with organisations like IOSH and CIRIA spending large sums of money to fund research each year. Other organisations at a corporate level, industry-sector bodies, and government-funded organisations spend even more. This takes the annual health and safety research spend to around £30 million.

This is the value of research to academia. This method of evaluation, however, underplays the true value of H&S research. The real value can only be captured if the research can be applied and used by industry to improve the H&S performance of organisations in the workplace. The crux here must be to unlock the 'added value' that application brings.

Research pushes the boundaries, establishes new theories, but can I, as a practitioner, apply it in the workplace? Will colleagues with an operational responsibility for health and safety be able to understand it such that it can be taken forward?

In recent years, a number of research projects have struck a chord with me on a personal note. All are characterised by the immediate relevance to the workplace. They are all underpinned by a strong industry link within the research programme.

Work at the HSE Health & Safety Laboratory (HSL) recently looked at how best practice in health and safety leadership and worker engagement could be identified and transferred elsewhere within the construction industry. Examples and practices captured from major contractors were developed into a toolkit, which is applicable to SME organisations.

IOSH-funded research carried out as part of the London 2012 Olympics captures best practice and articulates it in a format that can be understood by the non-practitioner. This, I believe, means that business leaders can understand it and support its implementation in their own environment.

Ongoing research at Loughborough University, funded as part of a wider programme, is looking at how knowledge is created in networked organisations. This relies heavily on studies of practices used in industries such as construction.

Projects like these are well placed to deliver added value, in part, because they are well connected to industry needs.

# Plenary session 3

## Thursday 02 October, 09.00–10.30

Chair: Harry Shannon, McMaster University, Canada

Room: Carrick Suite

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**Bob Wears**

University of Florida, USA / Imperial College London, UK

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### Improving safety by enhancing resilience

Resilience and resilience engineering are the most recent entries in a constellation of ideas about how to enhance safety: one that stands in contrast to the more rationalist Cartesian, Taylorist approach to safety and performance.

The 'classical' approach to safety (safety-I) is clearly the dominant idea in modern times, and it has attained the status of an orthodoxy. In addition, it must be admitted that this orthodox approach to safety has accomplished a lot in a variety of fields. It is basically an engineered approach, based on a few key assumptions: that our systems are well designed, maintained, understood, and protected; that accidents result from erratic, variable, defective components (mainly people); that solutions take the form of increasing constraints on variation through standardisation, barriers and policies; and that studying accidents is a useful route to learning. Its 'gods' have names like Taylor, Deming and Shewhart; its sacred myth is the Toyota production system

Safety-II, on the other hand, is a more organic, emergent approach. It proceeds from a different set of assumptions: that our systems and our understandings of them are "buggy" and incomplete, especially with respect to the possible failure modes into which they might evolve; that accidents result from unanticipated interactions of normally functioning components (including people); that solutions take the form of making constraints and goal conflicts more visible, and from enhancing the repertoire of possible responses; and that studying normal work is a useful route to learning. Its 'gods' have names like Rasmussen, Woods and Hollnagel; its sacred myths are stories such as Three Mile Island and Tenerife.

The difference between these two approaches is much more than choice of method; they are based on fundamentally different philosophies of science. Safety-I is modernist, flowing from the Enlightenment, and is based on the notion that the rigorous application of logic and rationality can both explain and control a world full of risk. Safety-II is post-modernist, flowing from the irreducible uncertainties of complexity, the "continuing expectation of surprise", and the notion that action-in-context can influence (but not control) an uncertain, conflicted and contingent world.

Resilience is clearly a safety-II approach; one that says: given that it is impossible to even imagine, much less defend against, the ways in which things might go wrong, the best strategy is not to invest in increasingly elaborate barriers against increasingly improbable possibilities, but rather to enhance the system's ability to respond effectively to the unexpected – to favour investment in mitigation and recovery, over investment in prevention.



## **Improving the health and safety of workers – the crucial role of research**

The theme of our conference – “learning from the past to shape a safer future” – is a simple phrase, but immersed in its seemingly straightforward words is an enormous wealth of implications for safety practitioners and researchers. And these implications are definitely not simple. Not only is there complexity in the science of individual and organisational learning, but also the very subject matter of safety covers an almost unlimited diversity of work activities, organisations, countries, and, of course, risks. The most important underlying aspect for me, however, is that, at its conclusion, the words “safer future” depict a world in which there are less tragic consequences for people at work, the communities in which they operate, and, indeed, the environment.

The quality of research is often measured by academic standards, and we need the thorough and rigorous process of peer review to provide a strong evidence base. This is not, ultimately, an academic issue, but a human story. In the world of health and safety research, we explore new techniques, analyse data, look for solutions to pervasive and emerging issues, and, ultimately, provide the evidence base for furthering the safety of our society.

These benefits, however, will only arise if we are effective at translating research outcomes into practice in the world of work, and this is not easy. The challenges of organisational learning have been repeatedly demonstrated, as accidents with similar causes have recurred, and organisations’ – and, indeed, individuals’ – failure to learn is one of the most problematic issues in the management of safety. Accidents are just one source of learning and, alongside best practice and purer research, provide insights for practitioners and managers that should be a rich source of help in keeping people safe. However, as has frequently been shown, we’re not good at it.

We invest significantly in safety research, and the diversity of papers presented to this conference demonstrates the richness of information available. From the supranational EU 2020 fund, through national governments and research councils, regulators, professional institutions, charities and companies, we make an enormous commitment to research, and this commitment places a great responsibility on us all to extract the value from it.

I believe this responsibility is getting increasingly important for three reasons. First, the world is dramatically changing. Technology is advancing and radically new materials, processes and industries, such as distributed manufacturing, synthetic biology and nanotechnology, are introducing new and, in many cases, unknown risks. The world is also becoming more interconnected as global supply chains change the shape and nature of distribution, bringing added complexity and, potentially, new risks. The speed and scale of data processing and social networks add to these complexities.

Second, the world’s economies have been through unprecedented volatility and, although we are now in a period of relative stability, pressures on companies’ finances are still significant. While everyone at this conference may be in no doubt about the value of effective safety management, it still faces the challenge of stating its case alongside other business priorities.

And finally, as mentioned earlier, safety is about people, and the stark differences in accident rates across the world suggest to me that we need to be much better at sharing and learning across boundaries. In a civilised world there really should be no excuse for such stark disparities.

I believe there are three areas in which we could improve in translating research outcomes into practice, thereby improving the safety of people.

First, how we coordinate the significant volume of research referred to earlier. I would like to see a greater degree of collaboration and understanding of the priorities between the different interest groups, and conferences of this type must be a great contributor to that aim.

Second, how we collaborate between researcher and practitioner, and ensure that the practical needs for research are accommodated in research programmes, and that practitioners are aware of the opportunities that research outcomes offer.

And finally, probably the hardest area of all referred to above, improving the way we learn from research. I believe we should see research as a critical third corner in the knowledge triangle, together with sharing best practice and learning from our mistakes. Here, I believe, is an opportunity to raise the profile of research and its benefits by placing it alongside the other knowledge themes.

In summary, in such a fast-changing world, amid conflicting priorities, we have a great responsibility to improve our collaboration, coordination and learning of safety research, as, ultimately, this is about preventing injury, suffering – and potentially – tragedy.

# Plenary session 4

## Friday 03 October, 11.00–12.30

Chair: Walter Eichendorf, German Social Accident Insurance (DGUV), Germany

Room: Carrick Suite

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Adrian Suarez

European Agency for Safety and Health at Work (EU-OSHA), Spain

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### Foresight of new and emerging occupational safety and health (OSH) risks associated with new technologies in green jobs

#### Objectives

The EU is working to balance economic growth with the need to protect the environment. This has resulted in growth of the green economy and a rise in the number of green jobs available. For these green jobs to be truly sustainable there is a need to ensure that they provide safe, healthy and decent working conditions for their workers. With the expected further growth of these green jobs, now is the opportunity to anticipate any new OSH risks before they appear. EU-OSHA's foresight attempted to identify new and emerging OSH risks from new technologies in green jobs, in order to ensure safer and healthier workplaces. This is in line with the objectives of the Community Strategy 2007-2012 on Health and Safety at Work to anticipate risks associated with new technologies, and the EU2020 Strategy to reduce the environmental impact while promoting OSH as a condition to job quality and to smart, sustainable and inclusive growth.

#### Methods

Two literature reviews, consolidated by 50 phone interviews and two online surveys, resulted in the selection of key drivers of change that could shape green jobs and key new technologies likely to impact on OSH in green jobs. This was followed by eight technology workshops that explored potential new and emerging OSH risks for each of the key technologies identified, and discussed ways in which to address them. Overall, 170 people were involved.

#### Results

This foresight identified OSH risks specific to wind energy, small-scale renewable-energy generation, batteries, bioenergy, waste treatment, green transport, green construction, and green manufacturing.

It also revealed common challenges to green jobs, such as a trend towards decentralised processes and workplaces that created a challenge to monitor and enforce safe working practices. This is the case of distributed, small-scale renewable energy installations, which, especially when installed by new, unskilled entrants in the sector, are likely to be non-standard installations hazardous to maintenance workers. Time pressures generated by environmental subsidies and their withdrawals may additionally contribute to OSH being overlooked.

Another challenge is the conflict between OSH and green objectives, with the latter taking priority. We tend to associate the word 'green' with safety, but what is good for the environment is not necessarily good for the health and safety of workers who are employed in green jobs. In some cases, new

legislation and technologies have been designed to protect the environment, resulting in workers being put at greater risk; for example, reducing the amount of waste being sent to landfill has resulted in higher rates of accidents and illnesses among workers whose job it is to process it.

New technologies or working processes associated with green jobs can also lead to new hazards, which call for new combinations of skills to deal with them: the 'old' OSH knowledge cannot simply be transferred to them; for example, installing a solar water heater involves combining the skills of a roofer, a plumber and an electrician.

The release of new materials along the lifecycle of green technologies and their products, particularly during their end-of-life processing, is also an issue. Exposure to new materials, such as biomaterials and nanomaterials, needs to be closely monitored, in particular, for long-latency health hazards to workers exposed to them.

### **Conclusion**

The new settings, conditions and combinations in which OSH risks are found in green jobs, and the new groups of workers involved without adequate OSH training, bring new challenges. These call for new OSH skill sets and the raising of awareness among employers and workers.

When devising prevention for green jobs, the specificities of the various green jobs and worker groups have to be taken into account. In the workplace, risk assessment remains key to this need.

Finally, a systematic prior assessment of OSH over the lifecycle of any green technology, product or process is needed at the design stage. This requires cooperation of various actors across several disciplines.

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**Joy Oh**

Ministry of Social Affairs and Employment, Netherlands

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## **The power of the regulator: can the regulator play a role in the development of health and safety science and the health and safety profession?**

In this keynote, the role of the regulator in the agenda-setting process of safety at work will be discussed in relation to the paradigm shift from government to governance.

In the policy field of health and safety at work, paradigmatic shifts in thinking on the role of government are quite noticeable. Regulators have to be able to navigate within these various discourses to get the topic of safety at work on the political agenda. In this process, disasters and incidents, such as Piper Alpha, Seveso, Enschede, and Toulouse, can be important social drivers. Regulators can use them to create urgency for their policies and influence national politics and society by choosing the right framing of the policy issue. In the process of policy formation, special attention must be paid to collaboration between regulators and the scientific community – and especially to the non-corresponding expectations of these actors and the application of scientific knowledge in policy.

The aspects mentioned above will be discussed with reference to specific cases, which originate from three decades of experience as a regulator at the Dutch health and safety policy directorate.

# Technical sessions TS1–TS3

## Wednesday 01 October, 13.45–15.15

### Technical Session 1: Safety theory, models and data analysis

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#### 1. StoryBuilder and Dutch SafetyIndex: evidence-based practice measuring safety management

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**Adri CP Frijters** – Arbouw Foundation, Netherlands

Arbouw is an expertise centre for occupational circumstances in the Dutch construction industry. Arbouw provides employers and employees in this industry with information and instruments to improve the safety and health standards.

In the past, Arbouw has developed and introduced several instruments, among which are the Dutch SafetyIndex and StoryBuilder Construction. In earlier WOS conferences, the development of these instruments was presented. The Dutch SafetyIndex was introduced at the WOS conference of 2008. In a paper and presentation, the development and test method were described.

The Dutch SafetyIndex is based on the Finnish TR method. With this instrument a construction company is able to measure its performance on occupational safety, thereby avoiding occupational accidents. It consists of a scorecard (paper or online) for the main hazard topics in the construction industry. Workers on the construction site observe a situation, and then score for relevant aspects if the situation is safe or not. The results can be discussed in toolbox meetings (during site safety meetings). Results of different SafetyIndex sessions can be compared. This means that differences in time on one site and differences between other sites (benchmark) can be compared. The SafetyIndex was introduced in the Netherlands in April 2010.

In a presentation during the WOS conference of 2010, the method of and theory behind StoryBuilder Construction was presented. StoryBuilder Construction is an instrument by which occupational accidents can be registered, analysed and prevented in future. This can be done at company level but, since registered accidents can be anonymously shared, it can also be done at a national level, giving valuable input for safety policy at branch level.

This instrument is based on the WORM project (WOS 2008, WOS 2010, WOS 2012) of the Ministry of Social Affairs and Employment. It was introduced in December 2012.

The Dutch Safety Index and StoryBuilder Construction are useful instruments. Developing these instruments, however, is not enough to improve safety standards in companies and in the construction industry as a whole. In order to reach that goal, the instruments have to be used. Special communication plans were developed and executed to introduce the instruments to the companies and encourage their use.

In part, the government supported this implementation through the Action Plan Occupational Safety of the Ministry of Social Affairs and Employment.

In the paper and presentation delivered at the WOS 2014, delegates will be given an overview on the introduction process of both instruments. The communication plans and their execution will be discussed. We will describe in what way we facilitated the companies in their attempt to incorporate the instruments in their safety management system. Using the instruments, companies are able to lay hands on safety performance and causes of accidents. We can also give delegates a national level on the outcome of this safety performance and the causes of accidents.

The results of those activities are described and will be followed by conclusions and planned activities.

The aim of the paper is to exchange experiences and information about implementation of safety instruments for the benefit of a higher safety standard in the construction industry.

*Keywords: Instruments, measuring safety, accident analysis, accident registration, improvement of safety*

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## 2. Identification of the most endangered groups of workers and types of work through statistical analysis of data on accidents at work

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**Szymon Ordysiński** – Central Institute for Labour Protection – National Research Institute (CIOP-PIB), Poland

### Background

Recent figures show that, on average, every week in Poland more than 1700 accidents at work happen and almost seven workers are killed as a result of accidents in the workplace. Relevant regulations of the European Parliament and the Council of the European Communities oblige Member States to keep a list of accidents at work. In Poland, accidents at work are registered by Polish Central Statistical Office (GUS). The survey carried out by GUS includes all accidents at work of persons employed in almost the whole Polish economy, regardless of whether the accident has caused work disability or not. The survey is conducted with the use of an 'Accident Statistical Card' form, which is harmonised with European Statistics on Accidents at Work methodology. The mere collection of data on accidents at work is insufficient, so it is necessary to conduct statistical analysis. Through identification of the most endangered group of workers and types of work, statistical data analysis of accidents at work enables one to adequately orientate efforts of preventive actions. In this paper, the results of statistical analysis of accidents-at-work data, which were carried out by the Central Institute for Labour Protection – National Research Institute, will be presented.

### Novelty

To identify types of work with the highest risk of accidents at work, the TwoStep Cluster Analysis was conducted. Cluster analysis is a multivariate method that reveals natural groupings within a data set that would otherwise not be apparent, according to a number of variables at the same time (age, sex and occupation of the victim, working environment of the accident, physical activity performed by the victim, number of workers in an enterprise, and other circumstances of the accidents). Therefore, it is a natural improvement of a simple identification of the most hazardous types of work based only on one characteristic – for example, according to the incidence rate in an economic activity of the enterprise.



The analysis of the most common courses of an accident at work was conducted using multivariate methods that allow for the identification of the entire course of accidents. The analysis in identified types of work was made using Market Basket Analysis (Association Rules Analysis) in specific age groups by Classification and Regression Trees Method.

### **Methods and findings**

As a result of the TwoStep Cluster Analysis, three types of work were identified and well profiled (accidents in the same group are more similar to each other than to those in other groups), with different numbers of occurred accidents of various severity. The cluster analysis allowed for a proper study of the most common courses of an accident at work in identified types of work. The analysis was made using Market Basket Analysis (Association Rules Analysis) and its results will be presented.

Moreover, the results of an in-depth analysis focusing on victims of accidents at work will be presented. The frequency distribution of accidents at work and the incidence rate based on the age of injured persons and tenure have shown that the highest risk of occupational injury is among young (but not the youngest) and inexperienced employees, and old (but not the oldest) workers. The frequency distribution of accidents at work based on victims' age is close to a 'U' shape. Furthermore, older workers have significantly higher risk of more severe consequences: longer incapacity to work, and higher probability of death as a result of an accident. An in-depth analysis of the most common causes and courses of an accident at work in particular age groups (conducted using descriptive statistics and Classification and Regression Trees Method) reveals that workers in certain age groups are more exposed to certain types of accidents. Examination of circumstances of the accidents based on victims' age and tenure showed that older and experienced workers are more frequently employed for hazardous tasks and, therefore, they are more often injured while performing those tasks that carry high risk of an accident.

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## **3. Model for analysis and prevention of work accidents – MAPA: an organisational perspective**

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**Rodolfo AG Vilela** – São Paulo University; **Alessandro José Nunes da Silva** – Workers' Health Reference Center; **Manoela Gomes Reis Lopes** – University of São Paulo; **Marcos Hister Pereira Gomes, Eduardo Buoso** – Workers' Health Reference Center; **Ildeberto Muniz Almeida** – Botucatu School of Medicine, State University of São Paulo, Brazil

Work-related accidents are the most harmful to the health of Brazilian workers. They are complex and multi-causal events, with their main origins in work organisation and processes. This statement goes against the traditional paradigm, which assigns accidents to worker error, thereby hindering their prevention. Accident analysis is an opportunity for organisational learning, and to understand the invisible origins and avoid new events. From this perspective, our research staff have developed a model for analysis and prevention of work accidents (MAPA). MAPA was tested in a joint effort with the researcher team and the Center of Reference in Worker's Health – of Piracicaba, São Paulo, Brazil. Contributions from current knowledge, such as a 'bow-tie' model, ergonomics of activity, change analysis, and barriers analysis, were adopted into the development of MAPA. The model has been tested in more than 100 work accident analyses, including work health surveillance and academic investigations.

## Objectives

To describe the model, report a case of accident analysis, and present preventive possibilities and challenges to the MAPA application.

## Method

Qualitative and descriptive study on the development and test of the model. We also interviewed analysts about the use of MAPA and its main benefits, drawbacks, and how they face and solve these problems.

## Results

Major steps of MAPA are: a) description of habitual work as supported by ergonomic concepts highlighting variables and strategies used to face them; b) description of the accident based on changes analysis, barriers analysis, failures in management of safety/production, and conceptual enlargement. Finally, it includes an evaluation of latent origins of accidents and suggestion of preventive measures.

## Application case

A work accident occurred with a power-press machine in the automotive sector. A new and pregnant employee was extracting a piece from the press zone and had her right hand caught in the mechanism when the press hammered down. Normal work and changes analysis revealed the worker was a beginner in this workplace and she had not received training in this new duty. She was replacing a colleague who had been moved to another machine. The study showed that the piece-extracting system hindered the worker's ability to operate the machine because its magnetic system required greater strength from the operator, and the workplace was not set up for a worker of this biotype.

The experienced operator was taller and had developed a *modus operandi* with high speed. Inside the company, the power-press operation is considered a simple and banal task. If the operator knew its sequence of steps then she would be considered prepared to operate the machine. Barriers analysis revealed that the machine had all safety protections required by Brazilian protection regulations, but it was purchased with faults inside the hydraulic-cylinder seals system, which was responsible for forcing down the hammer, even if a worker's arms and hands were inside the risk zone. The degraded mode of operation was maintained and the use of an untrained employee exposed the vulnerabilities of the safety system. For six months the power press was used in normal operation, even with a leakage of oil in its hydraulic system because the problem did not cause a break in production. The stopping of the machine for repair was seen as a cause of delays in deliveries, according to the principles of lean and flexible production ("just in time").

With the enterprise operating at the threshold of current installed capacity, the safety and health management system was reduced to specific and bureaucratic actions in submission to the interest of production. Analysis of the management system showed that the maintenance department was obligated to prioritise the set-up of machine tools to attend to the changing and urgent production goals established by the vehicle assembler's demands, and that fixing defects of machines was secondary. In automotive chain production, target dates and goals are established by the assembler. If they are not met, the supply companies could be fined or lose their contracts. After the analysis the safety and health surveillance team prohibited the use of the machine until the problem was fixed. The main preventive challenge is how to evolve the automotive supply chain and the assembler company to establish organisational modifications in the whole process to avoid accidents and occupational-health problems.

Interviews with the worker's health surveillance team allowed the collection of preliminary perceptions of analysts about the use of MAPA. All respondents knew and applied this tool. The main perceived advantages are the systemisation of analysis of barriers and changes analysis. The method also facilitates the presentation of results for companies, contributing to adhesion and changes in circumstances

that led to the accident. The greatest difficulties are: the long-term nature of research and writing the reports; how to protect the informants, because the analyst cannot expose them to the hierarchy of organisations; and, finally, the aspects related to negotiation of the necessary preventive changes in the workplace. Adherence to results occurs especially when the recommendations are grounded in existing standards and obligations, and greater resistance occurs during the changing of managerial and organisational aspects identified in the origin of accidents.

## Discussion

According to our analysis, management had a false comprehension of the operator's real work and this view influenced the decision to assign the pregnant worker to operate the machine. Who had taken the decision of maintaining in operation a machine presenting defects for almost six months, and how had this decision come about? Did the safety team participate in this process? What should be done to establish the necessary balance between the assembler company's demands and the real existing resources in the supplier's enterprise? The model helps unveil weaknesses in the traditional approach and explains contributions in managerial failures, in the conception of technical systems, and in management in labour safety. It encourages broader analyses of preventive measures anchored in improvements in production and in the management of its variability.

*We acknowledge the support from Research Foundation of São Paulo State (FAPESP – Protocol n° 2012/04721-1) and Public Minister of Labor (15ª Region, São Paulo).*

*Keywords: Method for accident analysis, research in practice, accident prevention, organisational analysis*

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## 4. Capturing safety awareness through diaries

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**Ross Davidson, Colin Pilbeam, Noeleen Doherty, David Denyer – Cranfield School of Management, UK**

The UK services sector employs the majority of workers in today's Britain (UK Office of National Statistics, 2013), yet, based on literature searches of the safety research, studies that identify safety practices and describe how these practices are enacted in low-hazard organisations (LHOs) over time are rare. This current study presents participant diaries as an approach that will allow these practices and their enactment in LHOs to be investigated in real time in their natural setting.

By capturing safety practices in real time, the accuracy of information provided can be improved. Because the time between an incident and its reporting is reduced, retrospective bias can also be reduced, thus helping ensure more accurate memories of incidents (Bolger *et al*, 2003; Ohly *et al*, 2010).

Diaries as a data-collection tool have been used in two main ways. The more common usage in management research appears to be a quantitative approach (Symon, 2006). This approach addresses questions such as how variables change over time (Bolger *et al*, 2003; Ohly *et al*, 2010); however, these methods don't reveal details about safety practices or how they are enacted. As examples, Daniels and Harris (2005) used Likert-style self-report measures of trait effects, effects before and after work, daily demands, coping, and goal attainment to test which coping strategy best influenced the individual's wellbeing, among employees in London hospitals. Similarly, Harris *et al* (2003) asked call-centre employees to complete self-report measures about their wellbeing and goals.

An alternative approach, the qualitative diary, attempts to understand practices and the subsequent enactment of practices in detail. For example, Symon (2006) used activity mapping to understand the day-to-day practices and inter-relationships of members of an IT development team. Team members kept diaries that revealed activities and relationships, which would have remained hidden had Symon used a quantitative approach. Atewologun (2011) used a template analysis of the structured diaries kept by senior employees of organisations, who were from a minority group, to understand how they made sense of their multiple identities.

Three strategies to gather information are used in diary studies. Event-contingent strategies ask participants to respond immediately (or as soon as possible) after the event under investigation occurs. Signal-based strategies ask participants to respond to a predetermined signal. Finally, interval/time-based methods ask a person to respond at a fixed time or period of time (Bolger *et al*, 2003). Studies using diary methods to collect quantitative data favour a fixed schedule (Daniels and Harris, 2005; Weiss *et al*, 1999). Diary approaches gathering qualitative data are less consistent. Waddington (2005) used an event-contingent protocol to investigate gossip in the hospital workplace, whereas Symon (2006) pursued a daily fixed-schedule reporting protocol.

The quantitative diary format favours using shortened versions of validated Likert-type surveys permitting quantitative analysis of data (Daniels and Harris, 2005; Harris *et al*, 2003). Qualitative diaries used within management research prefer using set questions as prompts. This allows the researcher to gather in-depth knowledge that is focused on an issue, yet is also in a format that facilitates comparison. Symon (2006) asked participants to respond to specific questions about what they did each day at work. Waddington (2005) used an event-contingent approach and asked participants to record responses to specific prompts about a gossip incident at work.

Quantitative diaries lasted for approximately two weeks with twice daily responses (Daniels and Harris, 2005; Harris *et al*, 2003). Symon's (2006) qualitative approach lasted for one month with participants completing their diary daily. Buchanan and Boddy (1992) had change managers keep a diary for two weeks in which they described their experiences managing change within their organisation. Atewologun's (2011) participants kept diaries for approximately one month, making entries approximately three times each week.

An appropriate sample size depends on the diary method pursued. Studies recording incidents and using quantitative methods indicate small numbers of participants, because a few participants may accumulate many incidents if they occur frequently. For example, 29 participants recorded 221 incidents in the Daniels and Harris (2005) study. The Harris *et al* (2003) study had 22 participants with a total of 365 usable incidences. Ohly *et al* (2010) suggest a minimum sample size of 30. Bolger *et al* (2003) suggest sample sizes of around 100 participants for quantitative approaches to data analysis. These discrepancies in sample size may be due to the level of analysis used, desired statistical power, or desire to generalise findings and publish.

Atewologun (2011), Balogun and Johnson (2004), and Symon (2006) provide insight into an appropriate sample size for a qualitative diary study. Twenty-four senior managers completed identity journals in Atewologun's (2011) research. Balogun and Johnson (2004) asked 26 managers to keep monthly diaries for one year describing how they made sense of their organisation's restructuring process. In her study of an IT project, Symon used 22 people representing a wide cross-section of the project. Reis and Gable (2000) caution that some participants may consider the diary burdensome and intrusive and this may lead to non-completion.

Based on the previous discussion, the qualitative research diary is ideally suited to addressing the focus of this study, identifying safety practices and how they are enacted in real time in LHOs.

For this study, ten participants from each of four different LHOs representing front-line workers, supervisors and management are keeping individual daily diaries for two weeks. Using a modified event-contingent design, when safety at their workplace becomes salient, participants are asked to answer the set of questions provided using their voice recorder. Voice recorders allow participants to respond immediately, thus reducing retrospection concerns.

Methods of analysis are influenced by whether the diary method pursued is quantitative or qualitative. This research has identified a qualitative diary approach as most suited for our research. Symon (2006) identified major themes using activity maps. Waddington (2005) pursued a template analysis. This research will use template analysis, a structured technique for analysing qualitative data.

As has been presented, diaries offer a valuable alternate method to further develop our understanding of safety.

*Keywords: Low-hazard organisations, safety practices, safety diaries, longitudinal research*

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## 5. Designing an individual risk assessment tool based on registration data

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**Peter Berkhout, Martin Damen – RIGO, Netherlands**

In this paper, the occupational risk of individual employed workers is assessed using merged registration data. The analysis features a negative binomial-count data regression model for statistical inference. In the model the mean rate of accident occurrence per working day is determined by variables characterising the personal background and working conditions, such as age, sex, contract type, working hours, and sector. The estimated model is used to build a computer tool that assesses individual occupational risk. In this tool the entire Dutch economy is divided into 262 sectors of industry. Within these sectors individual risk varies with personal characteristics.

The main contribution of the paper to the literature is the fact that calculations are based solely on registration data and include the entire population at risk, comprising all employed workers registered to be living in the Netherlands in 1999-2011. Data were assembled by means of one-to-one match merging of complete registration data on individuals, jobs, firms and accident casualties. The research was initiated by the Dutch National Institute of Public Health and the Environment (RIVM), in order to identify long-term trends in serious occupational accidents in the Netherlands.

On average, the mean rate of occurrence of serious occupational accidents per working day is estimated at approximately  $1 \times 10^{-6}$ . This refers to accidents leading to permanent injury, hospitalisation, or death of the worker. The mean rate of occurrence has declined significantly over the period 1999-2011. As expected, risk varies strongly between workers. The 'identifiers of risk' in the model can account for an individual risk assessment at the 99%-percentile of the population, which is more than 1000 times the risk at the 1%-percentile. Risk is significantly related to age, sex, contract type, working hours, and sector. Typical high-risk groups are males, young and elderly workers, and flex workers. Results allow the selection of high-risk branches of industry. It turns out that 36% of all accidents are associated with 10 branches (out of 262), accounting for 14% of all jobs. Finally, occupational risk is positively related to the business cycle; the average rate of accident occurrence in an economic boom is 6% higher than in a recession.

*Keywords: Occupational risk assessment, serious occupational accidents, econometric modelling, mean rate of occurrence, registration data, high-risk groups, business cycle, risk tool*



# Technical Session 2: Hazardous industries

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## 1. Regulating the intangible. Safety culture and regulation in the Norwegian petroleum industry

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Stian Antonsen – SINTEF Technology and Society, Norway

The international petroleum industry has seen significant improvements in safety results over the last decades. This improvement cannot be attributed to any single factor but is likely to be the result of improvements in technology, methods for work performance, rules and regulations, etc.

Despite the improvements in technology and regulation, accident investigations repeatedly show that the softer and informal aspects of organisation can play a role in major accidents. This poses an intriguing challenge for regulators: are the intangible aspects of safety and organisation out of a regulator's reach, or are there ways a regulator can hope to influence the safety culture of companies in the industry?

Aiming to influence safety culture seems to involve a break with the logic of accountability and internal control. How can you formulate government requirements to the cultures of organisations? How do you regulate supervision, such as audits or verifications of a company's culture? Last but not least, how can you impose sanctions on a company on the basis of the company not having the 'right' culture?

These questions sum up the topics that will be discussed in this paper. Contrary to what one might think, we will show that there are actually three ways for regulators and regulatory authorities to regulate the intangible:

- Changes in framework conditions (e.g. rules and regulations, regulatory practice) changes the context in which organisational cultures are formed, and can thus contribute to cultural change. This, however, will be a process, which, by definition, will be both unpredictable and stretch over a long period of time.
- Introduction of policy statements in regulations. A regulatory paragraph can take many forms. Our study has shown how regulators may introduce paragraphs that are not used as basis for audits or statutory authority for sanctions, but which nevertheless provide direction for both the companies in the industry and the internal practice of the regulator.
- Non-judicial regulatory practice. Our study illustrates how the judicial, control-oriented function is not the only possible role of regulatory authorities. On the contrary, provided that the regulatory regime allows for it, a regulatory authority may take on a more proactive, informative role, in addition to its traditional control activities.

The paper sheds light on the way regulation and regulatory practice can regulate the more informal aspects of safety, and the way organisations' safety cultures are influenced by extra-organisational factors.

*Keywords: Regulation, safety culture, safety improvement, petroleum*

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## 2. Improving safety culture and safety management in the NSW Australian mining and extractives industry through action research

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**Heather Jackson** – University of Newcastle, NSW, Australia / Mine Safety Assistance Unit, Mine Safety Performance, NSW Trade & Investment, Australia

High-risk industries are faced with the challenge of managing low-frequency, high-consequence events, as well as personal or occupational injury and disease. Safety climate measures and safety culture assessment have been proposed as possible leading indicators of work health and safety (WHS) performance. Despite more than 30 years of research there is still no agreed method or 'gold standard' for the assessment of safety culture.

The dynamic nature of both a safety culture and WHS management systems makes it difficult to demonstrate an association between safety culture and safety performance. A report on the Pike River mining disaster in New Zealand in 2010 highlighted some of the mechanisms through which an organisation's safety culture may contribute to deterioration in a health and safety management system. The challenge is to develop a method of assessment that can identify the signs of a deteriorating safety culture and WHS management system before a major incident occurs.

### Study design and methods

This paper will present the design and first-stage results of an action research project involving the Australian NSW Trade & Investment, Mine Safety Regulator and NSW mining and extractives industry. In 2008, industry leaders committed to achieving a world-leading safety culture by 2018. The Mine Safety Advisory Council, the main health and safety consultative body, commissioned the development and pilot of a self-assessment method and a baseline report. Three measures of safety culture were recommended for inclusion in the safety culture self-assessment protocol. These measures include a safety climate questionnaire (NOSACQ-50), a safety culture focus group, and a workshop assessment of health and safety practice. An action research partnership has been established to facilitate the self-assessment by company safety professionals and representatives. The aim is to drive continuous improvement in work health and safety and monitor industry progress towards the goal of achieving a world-leading health and safety culture.

Through the action research partnership between the regulator and industry, the study will evaluate whether mine and quarry personnel gather accurate data about their health and safety culture. The internal validity of the safety-culture self-assessment results will be compared with a direct safety performance measure, such as a balanced scorecard comprising lagging and leading measures, to test the proposition that a safety climate/culture is a useful leading indicator of safety performance. The general proposition that safety culture is a leading indicator of safety performance will be tested through a cross-case analysis of the multiple case-study findings.

The study adopts a multiple case-study design and the research objectives associated are to:

- establish the construct validity of the self-assessment tools and method by testing the findings against a proposed safety culture framework, e.g. are the tools measuring safety climate and safety culture?

- determine whether internal and external predictive validity of assessment data can be demonstrated by linking the assessment findings to safety performance;
- evaluate whether site personnel can apply the tools and method to make an accurate assessment of their safety culture and use the information to plan improvement strategies;
- establish an industry database to monitor and report on progress; and
- test the effectiveness of an action research partnership between the regulator and industry as a means of driving continuous improvement.

The research demonstrates the impact of research in practice in several areas:

- the experimental approach to facilitating industry-wide safety culture change through an action research partnership with the regulator;
- the industry-wide multiple case-study design employing triangulation of several data sets, including both quantitative and qualitative data; and
- the adaptation of the scientific method to the case-study research design to test the proposition that safety culture is a leading indicator of WHS performance.

## Results

The lessons learned from the preliminary- and second-phase trial will be presented and discussed (data collection in 2013, and spring 2014). Results will include an analysis of approximately 1,500 completed NOSACQ-50 questionnaires, together with an estimated ten focus groups and health and safety practice assessments. Industry programmes proposed for development, based on the evidence emerging from the culture assessment findings, will also be discussed.

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## 3. Behaviour-based safety systems in mines and dock work

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**David Walters** – Cardiff University, UK

Case studies in two very different sectors reveal quite similar approaches to managing workplace health and safety, in which behaviour-based systems predominate. Drawing on interviews and documentary evidence, this paper examines practices in several container terminals located in different parts of the world and operated by large global-network terminal operators (GNTs), and in a number of coal mines in Queensland, which are operated by large mining concerns. The perspectives of workers and their representatives have been sought concerning the operation and effectiveness of the approaches towards protecting their health and safety at the workplaces where they are employed. The study identifies a number of tensions between the systems adopted by companies to manage health and safety in these worksites, the requirements of the regulatory framework in which they are situated, and the perceptions of workers and their representatives concerning their relevance and effectiveness.

*Keywords: Behaviour-based safety, worker participation, mining, dockwork, effectiveness*

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## 4. Soft causes with hard consequences: the role of organisational factors in the creation of structural integrity

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**Elisabeth Lootz, Terje Andersen** – Petroleum Safety Authority Norway; **Jens C. Rolfsen** – Safetec Nordic AS; **Stian Antonsen** – SINTEF Technology and Society; **Stein Haugen** – Norwegian University of Science and Technology; **Jan E Vinnem** – University of Stavanger, Norway

### Topic

There has been an increasing number of reported structural and maritime incidents on the Norwegian Continental Shelf (NCS), with two particularly serious heeling incidents at the floating facilities Floatel Superior and Scarabeo 8 in 2012. Historic accidents, such as the loss of the Alexander Kielland platform in 1980 when 123 people died, have forever changed the perception of safety and the potential of structural and maritime incidents in the petroleum industry. This, together with a number of tragic international events in recent years, such as the Kolskaya accident, which left 53 dead in 2011, has made the Petroleum Safety Authority Norway (PSA) initiate a comprehensive study into the causes and possible mitigating measures related to structural and maritime incidents. It has been important to conduct the systematic collection and processing of relevant and available data. The data consists not only of written material but also that collected from interviews and questionnaire-based surveys answered by company experts, with updated insight and experience from a wide range of companies. This has been emphasised to gain insight into events that often develop in complex organisational interfaces involving multiple organisations. This study is aimed at parties involved in petroleum activities on the NCS, but it is considered relevant both to similar operations worldwide and international research on major accidents.

The study is currently being performed by a dedicated interdisciplinary research group from the Safetec Nordic, University of Stavanger, the Norwegian University of Science and Technology, and SINTEF, on behalf of, and in close cooperation with, the PSA.

The study contains analyses of data with relevant theoretical and practical experience contributions based on:

- a literature review of national and international research/other relevant written material related to reported incidents on structures and maritime systems;
- review of investigations conducted on causal events related to structures and maritime systems 2000-2013;
- the undertaking and analysis of in-depth interviews with key personnel within operating oil companies, shipping companies, engineering companies, and relevant suppliers regarding the causes and possible mitigating actions; and
- the undertaking and analysis of a broad questionnaire-based survey aimed at professionals within a wide range of operating companies, shipping companies, engineering companies, and relevant suppliers, regarding the causes and possible mitigating actions.

The following main questions are of particular interest:

- what are the key human, technical and organisational causes of structural and maritime incidents?
- what are the most important measures proposed/implemented to reduce the severity and number of

- structural and maritime incidents?
- is there correspondence between identified causes and proposed/implemented measures? and
- are proposed/implemented mitigating measures in agreement with causes identified in investigations and from experience?

The main purpose of the study is to describe the key challenges the petroleum industry has to face in order to reduce the severity and number of structural and maritime incidents in the future. One preliminary finding, after reviewing international research, is that there are very few studies on this topic. That finding makes the present study particularly interesting, relating to the identification of relevant risk-reduction measures for the petroleum industry, and as a contribution to international research by presenting insight into complex causes. The study was completed in April 2014 and will describe the challenges the petroleum industry could face in order to reduce the number of structural and maritime incidents. These updated findings will be presented in the final paper and at the conference.

*Keywords: Major hazards, petroleum industry, structural and maritime incidents in complex inter-organisational systems*

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## 5. Improving safety-through learning? The follow-up study from the oil and gas industry in Denmark

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### Background

The offshore industry in the Danish sector on the North Sea has always focused on reducing work-related accidents. In the period 2008-2012, three oil and gas companies in the Danish sector participated in a project about the possibilities and challenges in accident prevention. The study identified possibilities in: focusing on safety; the development of procedural systems, which provides guidelines for the employees; safety organisations; and safety awareness among employees. The challenges, however, were found in: lack of focus on structural/organisational factors to prevent accidents; lack of support from management in certain areas; lack of long-term strategy to prevent accidents; and lack of follow-up on, and evaluation of, actions taken. The overall conclusion was that while the Danish oil and gas industry is promoting accident prevention, there is still room for improvement.

The aim of the follow-up study is to find out if the oil and gas companies in the Danish sector have learned from their experience and improved safety, or if they are still on the same level as they were in 2010-2011 when the data was collected. The focus in the study is on learning from experience, and how the companies have developed during the last four years.

### Data

Data consists of an online survey, documentary data-like procedures, rapports, etc, as well as interviews and observations during safety meetings. Data comes from two oil and gas companies in the Danish sector of the North Sea, and were collected at the beginning of 2014. In 2010, all three companies participated in the project, but in the follow-up only two of the companies agreed to participate, which means that data from the third company will be removed from baseline.

## Methods

The study uses both quantitative and qualitative methods. The focus in analyses of data from the latest survey will be compared with the results from the survey conducted in 2010 (t-test or ANOVA). The interviews, observations and documentary material will be analysed in the same way as the data was analysed in the former project, with the aim of exploring development and learning during the last four years.

## Preliminary results

The preliminary results show the companies still focus on safety and try to learn from their experience. One of the companies started a new safety programme that focuses on more involvement from management and employees in safety issues. The aim of the programme is to change the attitude to, and understanding of, safety. The second company has expanded during recent years and met challenges connected to this rapid growth.

*Keywords: Accident prevention, offshore, learning*

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## 6. Risk assessment for occupational exposure to chemicals in an electroplating industry

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**Marco Silva** – ISLA Leiria; **Miguel Corticeiro Neves** – ISLA Leiria / ULHT Lisbon, Portugal

Risk assessment for occupational exposure to chemicals should be one concern of all electroplating industries. The quantities and characteristics of hazardous substances and mixtures used require a risk assessment to ensure the protection of workers, and compliance with the legal requirements in this area. This paper aims to apply a general method (NTP 330) for this assessment and compare the results with the results obtained from the application of three qualitative methods of risk assessment of exposure to chemical agents (NTP 934, NTP 936 and NTP 937), all published by the Instituto Nacional de Seguridad e Higiene en el Trabajo Espanhol (INSHT). After a description of the risk-assessment methods applied, a comparative analysis of risk-level results and control measures to be implemented will be performed, with the aim of describing the advantages and disadvantages of each method and in what conditions it can be carried out. It is not the intention to replace quantitative methods with these methods, but rather to complement them and allow a first evaluation phase and an initial diagnosis of risk, allowing, in certain situations, the adoption of measures to control the risk without recourse to quantitative methodologies, which are very lengthy and expensive. In case of high risk, assessment should be more detailed and use methodologies for measuring the concentration of chemicals in workplace atmosphere, for comparison with the threshold limit values.

These methods are thus a valuable tool for the safety services of companies so they can anticipate risks inherent to their activities that have a risk of exposure to hazardous chemical agents. These methods are also a valuable tool bearing in mind the entry into force of the REACH and CLP Regulations, which oblige the annexation of scenarios of exposure to material safety data sheets of chemical substances and mixtures (for substances or mixtures marketed in quantities exceeding 10t/year). This implies estimations of exposure in each of the possible uses of the substance and comparison with levels of exposure that are considered to offer no risk to human health. This exposure estimation should be done through models that include variables such as the amount used, time of use, volatility, and existing preventive measures.

These exposure scenarios describe the conditions under which the chemical should be used and ensure the effective reduction of exposure – meeting, in this way, the objective of protection of workers from the risks of exposure to chemical agents in a work context.

In reality, the generalist methods do not allow full compliance with the requirement of constant risk assessment, as they do not contemplate the intrinsic properties of each chemical agent and the forms of exhibition.

It is concluded, therefore, that these are valuable instruments in the NTP phase of initial diagnosis of the risk assessment of exposure to chemical agents. The NTP 934 and NTP 936 methods, in addition to risk assessment, determine the applicable control measures, while the NTP 937 method accounts for the existing control measures, and, as such, it sets the value of final jeopardy, which can be used for monitoring the effectiveness of control measures implemented.

*Keywords: Chemical agents, chemical substances, electroplating industries*

# Technical Session 3: Sector case studies

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## 1. Occupational safety of Finnish artists

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**Susanna Mattila, Venla Räisänen, Pia Houni, Heli Ansio** – Finnish Institute of Occupational Health, Finland

The term 'artist' comprises many kinds of artists, whose work may vary greatly. Different artists have different work tasks and their work methods, work materials and work environments are heterogeneous. The safety aspects of artists' work also vary depending on the artist type, and according to specific projects.

The safety of visual artists' and theatre artists' work was examined in the artists' wellbeing during the transition of an artwork project. The material was gathered through a survey in 2012. The aim was to determine the most significant safety risks in the work of artists. Among theatre artists the risk that especially interested us was that of people and objects falling to a lower level.

The questionnaire was delivered to 245 members of the Finnish Actors' Union, 607 members of the Artists' Association of Finland, and 117 actors, directors, dramaturges, light designers, sound designers, set designers, and dress designers of Theatre and Media Employees in Finland. Respondents were selected randomly, i.e. every fifth member was chosen. A total of 92 members of the Finnish Actors' Union, 272 members of the Artists' Association of Finland, and 40 members of Theatre and Media Employees in Finland responded to the questionnaire. The total response rate was 43 per cent. The questionnaire was sent electronically to those whose e-mail address was available. The remainder received a paper version.

Occupational accidents had occurred to 50 visual artists, i.e. a fifth of the visual artists who answered the survey. Of theatre artists, 69 had suffered an occupational accident, i.e. over half of the theatre artists who answered the survey. Visual artists were often hurt by sharp objects. Theatre artists' accidents often related to artists' movements and sudden physical loading, often resulting in sprains.

In their own opinion, the most significant safety risk in visual artists' work was exposure to chemicals – for example, to turpentine and other solvents. Theatre artists reported that the main accident risks were overbalance and tripping, especially in dark places with many objects, and electricity.

Two fifths of theatre artists had seen objects accidentally fall from the ceiling structure of a stage or studio. Usually the object was a lamp or other objects on lighting, or props. The most common reason for objects falling was poor attachments.

In total, 38% of the theatre artists had seen people accidentally falling to a lower level during rehearsals, performances, or filming. Usually the person fell off the stage. One common reason for this was inadequate lighting.

One fourth of the theatre artists had accidentally fallen to a lower level during rehearsals, performances or filming. This had happened, for example, on stairs, or from ladders and stages. Reasons for falling were, for example, incorrect behaviour either on the part of the artist who fell or some other person, awkward role clothing, or poor lighting.



The most usual solution to prevent falling to a lower level at the workplaces of the responders was railings. The use of fall-protection equipment and trusting artists' professional skills are also common ways of preventing falling.

This study provides a basis for work to promote the occupational safety of visual and theatre artists. It can help artists and their employers analyse and assess safety risks and choose effective preventive actions. The results can be used for developing stage standards, training, and enhancing supervisors' safety management skills.

*Keywords: Occupational safety, artists, theatre accidents, falling*

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## 2. Safety culture in three Norwegian haulage companies: best practices for managing transport safety

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**Tor-Olav Nævestad, Torkel Bjørnskau – Institute of Transport Economics, Norway**

### Background

It is widely recognised that safety culture is important for safety in organisational settings in hazardous industries (Nævestad, 2010), and the concept is applied to an ever-increasing range of sectors and industries. In the last few years, traffic safety scholars have started studying the role that safety culture may play in explaining and reducing risks in road transport (Nævestad and Bjørnskau, 2012). The safety culture concept may be applied to professional drivers, as they are members of organisations. Studies also document a relationship between safety culture and safety outcomes in transport companies (Bjørnskau and Nævestad, 2013; Zohar, Huang and Robertson, 2014).

### Aims

The present paper reports results from a study of safety culture among drivers in three Norwegian haulage companies (n = 224). The aim of the study is to test an assumption that the three companies have positive safety cultures and, provided that the assumption is true, to identify common characteristics of the companies' work on safety. We may thereby provide lessons for other haulage companies on how to develop positive safety cultures.

### Methods

Safety culture is studied by means of a questionnaire developed by the Global Aviation Network (GAIN). This questionnaire consists of 24 safety-related questions covering five presumably safety-relevant issues: 1) management's attitude and focus on safety; 2) the attitude and focus on safety among employees; 3) culture of reporting and reactions to reported errors and incidents; 4) safety training and education; and 5) general questions about safety within the organisation. The respondents answered all questions using a scale from 1 (disagree completely) to 5 (agree completely).

The safety culture index is computed as the sum of the scores of the 24 questions. This gives a minimum score of 24 and a maximum score of 120. 'Positive safety culture' ranges from a score of 88 to 120. The questionnaire also includes other questions on demographic background variables, working environment, accident involvement, private safety behaviour, sickness absence, and work-related factors with implications for traffic safety (e.g. employers' follow-up of drivers' speed, driving style and seatbelt use, stress, and pressure from employers and customers).

The safety work of the three companies has been studied by qualitative interviews with managers and the companies' union representatives ( $n = 7$ ). Company A has 450-500 employees, and transports dangerous goods in Norway and neighbouring countries. Company B employs about 85 drivers, and transports goods in Norway for well-established customers under long-term contracts. Company C has 190 drivers and transports goods in Norway for well-established customers under long-term contracts.

## Results

The study supports the assumption that the three companies have positive safety cultures. Companies A and C scored within the positive safety culture zone of the GAIN index ( $> 88$  points), while company B scored slightly lower. Company A has the highest score, while company B has the lowest score. The differences between the three companies are statistically significant ( $p = 0.028$ ).

We have conducted linear regression analyses to examine whether variables other than company may explain variation in safety culture among the respondents. In these analyses, we used independent variables such as age, private safety behaviour, and dichotomised company variables. Only the company variables significantly predicted safety culture. We also conducted logistic regression analyses to study independent variables (e.g. age, exposure, private safety behaviour, safety culture), predicting the respondents' accident and near-miss involvement.

The GAIN questionnaire on safety culture is universal, in the sense that the questions are neither sector- nor industry-specific. Consequently, we compared our results from the three haulage companies with previous results from studies of safety culture among helicopter and airline pilots, and bus and tram drivers. Interestingly, these comparisons reveal that company A scored somewhat higher than aviation on the safety culture index. This may not be surprising, however, as the activities of company A, which transports dangerous goods, is regulated by strict and comprehensive safety requirements, both from government authorities and transport buyers. Thus, the safety culture measures and the safety management system of company A stands out as a good example for other transport companies.

Our analysis identified the following common denominators of positive safety work in the three road-goods transport companies:

- follow-up of drivers' speed, driving style, and seatbelt use;
- managers' and employees' safety commitment;
- predictability;
- organisation of transport assignments;
- pay systems; and
- control of drivers' compliance with drive and rest rules.

Company A, which had the highest safety culture score, and stands out as a good example for other transport companies when it comes to safety management systems, also had comprehensive measures related to:

- safety training/education;
- arenas for safety communication;
- reporting culture and reporting systems; and
- safety management system.

We discuss if these measures can be adopted by other transport companies/road haulage companies.

*Keywords: Safety culture, haulage companies, safety management systems, safety culture development, transport safety*

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### 3. Implementation and integration of safety in the daily operations of a Danish haulage company

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**Mette Bach Hansen** – Technical University of Denmark, Denmark

Truck drivers face many hazards in their work environment. The frequency of accidents reported to the Danish Working Environment Authority for the haulage industry is 30 per 1,000 employed, with an estimated under-reporting of at least 50%. The Danish haulage industry covers about 6,000 companies, with about 33,600 employees. Despite a few large companies having more than 100 employees, the vast majority are very small. Eighty-nine per cent of the companies have fewer than 10 employees, and 97 per cent have fewer than 50.

Recent research shows that it is often difficult for the employer in a small company to find time and resources to prioritise safety, and it becomes increasingly difficult to ignore the dilemma between safety and production. To explore the dilemma it is necessary to understand how safety conflicts with a company's characteristics and the context in which it must operate.

The project investigates what are the challenges for Danish hauliers to implement and integrate safety in their daily operations. Furthermore, the project examines what characterises the management of Danish hauliers and how hauliers handle the dilemma between production and safety with which they are confronted.

The theoretical field in the PhD project consists of three parts. The first part is how to understand 'safety' and consists of theory about safety management, accident prevention, safety barriers, and risk perception. The second part is how to understand 'implementation and integration of safety' and consists of theory about safety interventions in small companies. The third part is how to understand 'a small virtual company' and consists of theory about business models, management in small companies, and distance management.

Two analyses are carried through. The first is an analysis of the risk perception among Danish hauliers and truck drivers to get a picture of the safety perception in the haulage industry. This analysis shows that although the haulier is aware of the risks in the truck drivers' work, it does not give rise to deeper reflection. The haulier does not see his or her influence on the occurrence of risks in the truck driver's work environment and it is mainly up to the truck driver to ensure a safe work environment. Hence, there is a need for an analysis of the daily management in a haulage company and what challenges the implementation and integration of safety into daily management.

The second analysis is a study of how the organisational design of the haulage company affects the safety level of the truck drivers. It is based on interviews with Danish hauliers about: safety strategy; implementation of safety strategy; assessment of the safety conditions at the customer site; function of the safety organisation; distribution of responsibilities for safety; technical safety and reliability of equipment; employee involvement in safety issues; dialogue about risks and safety; communication about safety on a daily basis; haulier involvement in safety issues; learning from accidents and damages; risk perception of haulier and driver; hauliers' rewards to employees for safe behaviour; hauliers' rewards to middle managers for focus on safety; competence needs; development of truck drivers' competence; introduction and instruction of new truck drivers; and hauliers' knowledge of legislation, rules and guidelines. This analysis can explain how the organisational design of a haulage company affects the working environment of the truck drivers. The result will show how a Danish haulier can redesign

the haulage company in order to achieve a safer work environment for the truck drivers, and how to implement and integrate safety in daily operations.

The project's future work will consist of a comparison and contrast study of a 'good haulier' and a 'bad haulier' in matters of safety issues. This analysis can explain how contextual factors, in both the haulage industry and haulage companies, influence the haulier's motivation for implementing and integrating safety in daily management.

The final results will show how a Danish haulier can implement and integrate safety in daily operations, and outline what can be improved and what is unchangeable.

*Keywords: Occupational safety, accident prevention, risk awareness, small companies, distance management, transport industry*

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## 4. Study on burnout syndrome within the Portuguese firefighters' population

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**Paulo Gaspar** – ISLA Leiria; **Miguel Corticeiro Neves** – ISLA Leiria/ULHT Lisbon, Portugal

The purpose of this study is to contribute to a better knowledge of the burnout syndrome within the Portuguese firefighter population. It will also refer to the relationship between burnout and work satisfaction. Although the overall intention of the work is to study the entire Portuguese firefighter population, in this stage only a sample of 39 individuals from the Alcabideche Firefighter Volunteers was studied.

There are multiple factors and sources of professional stress to which individuals are continuously exposed – factors relating to: the organisation and organisational culture, specific aspects of professional activity, and personal and interpersonal aspects. When professional stress becomes chronic, it can contribute, among other consequences, to the installation and/or development of burnout syndrome and depression.

The role played by firefighters today is fundamental in society, and presents specific features. They work in a relatively closed organisation, yet firefighters have a relevant social role in protecting the safety of populations. Performing this role effectively puts them under high levels of stress. There are few scientific studies on professional stress in Portugal.

The investigation follows the model of analytical epidemiological studies used to examine associations formed by hypothesis of causal relation. The main intention was to identify or measure the risk factors and their effects on the health of the operational firefighter within the Alcabideche Firefighter Corporation. A cross-sectional analytic study was used, as it analyses, at a particular moment, one specific population, and tries to establish correlations and interferences between selected variables chosen for their importance in relation to firefighters' health. A specific questionnaire adapted from the MBI (Maslach Burnout Inventory) method was used.

The analyses' results found no significant statistical correlation between gender, age and working hours and the three dimensions of burnout – exhaustion, cynicism and professional efficiency. This may be explained by the possible existence of protection factors, namely: social support, proper working conditions and good relationships among colleagues.

In the current study, it is interesting to note that a clear minority of firemen presents burnout (5.3), with low scores in emotional exhaustion, depersonalisation and personal fulfilment. A positive aspect, with a good environment and working conditions, is the good ability of firefighters to adopt positive strategies in resolving their problems, thus limiting the possibility of development of stress and burnout.

The proportion of firefighters with clinically significant burnout was reduced, having been only 5.3% of cases in the sample analysed.

In average terms, the emotional exhaustion manifested slightly low (18.05 M, DP 12.27), taking into account a minimum of 0 and a maximum of 54 points.

In relation to the average results obtained, the depersonalisation dimension (M 7.40, DP 6.51) revealed a low depersonalisation score, considering the minimum possible value of 0 and a maximum of 30 points.

Personal fulfilment, in accordance with the average results obtained (M 33.77, DP 7.03), observed a tendency for a higher personal achievement, taking into consideration the minimum value possible and a maximum of 48 points.

Finally, it was found that the majority of respondents worked as volunteer firefighters (57.9%), and that they have lower levels of emotional exhaustion compared with employed firemen.

There was no statistically significant correlation between gender, age and hours of work and the three dimensions of burnout, which could be explained by the possible existence of protective factors, such as social support, common good working conditions, and good relationship with colleagues.

*Keywords: Burnout, Portuguese firefighter, Maslach, MBI*

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## 5. Integrating occupational health and safety (OSH) within sustainability on a major construction rollout programme

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**Stephen Coppin** – Rider Levett Bucknall UK Ltd, UK

Government departments and non-departmental public bodies procure 40% of construction by value in the UK. Government procurement practices are a key influence on the performance of public-sector construction projects and the performance of the industry as a whole. In the UK, increasing pressure is being paid to how government departments procure construction works and influence sustainability (environmental) and occupational health and safety performance on their projects. Crown immunity, political pressure, unrealistic time and cost schedules, and experience in dealing with construction works frequently hamper the delivery of government construction projects.

The Department for Work & Pensions (DWP) has undertaken a rollout programme – a £750 million, four-year refit of government offices around the UK to deliver more than 1100 refurbished JCP premises.

This presentation is on how clients can successfully integrate occupational health and safety as part of their sustainability and corporate social responsibility (CSR) policy by developing and implementing a sustainable procurement strategy for the delivery of projects within a framework programme, built on the lessons learned from previous schemes. Also, the presentation will look at how this can be implemented with the contractors and suppliers using the processes, correct communication and consultation methods, monitoring, and agreed review. This delivery heavily focuses and depends on successful management and collaboration with the supply-chain team, with support of a core team supported by other specialists as necessary.

Adopting a holistic approach to sustainability procurement enabled early involvement of the supply chain in the design, providing greater opportunities for innovation to improve quality, safety, efficiency and reduced whole-life costs emphasised by the following drivers:

- sustainable procurement and design;
- enhancing co-ordination early within the design, project team and supply chain;
- implementation of integrated project teams and the spirit of partnering;
- establishing a risk-management register with a gateway process;
- establishing a separate code of practice for asbestos management and control of surveys, and separately managing the removal of asbestos;
- design risk management – through British Research Establishment Environmental Audit Measurement (BREEAM) or Building Information Modelling (BIM), etc;
- setting project specific standards through a joint environmental health and safety (EHS) code of practice;
- improving communication, consultation and participation with all three tiers of the supply chain;
- the provision of behavioural-based safety within a mandatory passport training scheme;
- extensive training of project team staff and designers with the Health & Safety Executive (HSE);
- delivery of an integrated site waste management initiative through working with Waste & Resources Action Programme (WRAP); and
- environmental health and safety (EHS) auditing, as part of the key performance indicators (KPIs) on contractors' and teams' performance.

*Keywords: Occupational health and safety and sustainability procurement, construction design and management (CDM), asbestos management, competence, behavioural, training, benchmarking and monitoring performance*

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## 6. Foreign actors transporting goods on Norwegian roads and at sea: an estimation of accident risks and discussion of risk factors

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**Tor-Olav Nævestad, Torkel Bjørnskau, Inger Beate Hovi, Elise Caspersen, Ross Phillips** – Institute of Transport Economics, Norway

### Aims

The main aims of the study are: to assess the accident risk of Norwegian and foreign actors in road and sea transport of goods in Norway; and to discuss the results in light of risk factors identified by means of a review of the existing literature. The accident risks are discussed in light of: 1) safety culture; 2) training and competence; 3) technology; and 4) framework conditions. Sea and road sectors are compared as the former is open to foreign actors, while the latter restricts foreign actors in accessing the domestic Norwegian market for goods transport.

### Background

Global and European market pressures have led to an ongoing increase in the shares of foreign actors in the Norwegian transport sector. The share of foreign lorries transporting goods in and out of Norway is growing, and data from the National Public Roads Administration and the Police indicate that foreign actors, especially from Eastern Europe, are over-represented in accidents.

Today, the number of foreign actors involved in domestic road transport of goods in Norway (cabotage) is profoundly limited by Norwegian regulations, such that it accounted for only 0.1% of total domestic freight transport in 2010. In the Norwegian maritime sector, on the other hand, cabotage is not restricted. In recent years, the European Union has been undertaking efforts to gradually lift restrictions on cabotage in road transport among its member countries. The rationale is that cabotage restrictions go against the spirit of a single European market. Owing to complaints from several member states facing competition from new EU countries with low labour costs, this process was put off until 2015, when a newly elected EU Commission will be in place. Social dumping and national competitiveness were the main concerns raised by member states, while little attention was given to the issue of transport safety.

Given the low level of wages in new EU member countries it is likely that relaxation of cabotage restrictions will dramatically increase the share of Eastern European lorries in Norway. To ensure that these lorries do not result in a disproportionate increase in accident risk on Norwegian roads, it is important to survey their accident risk factors and regulate to control them as necessary.

Since the 1970s the transport of goods by ship has been increasingly internationalised. The domestic transport of goods at sea in Norway is open to foreign actors, and port statistics show an increase in internationally registered ships in domestic and international traffic in Norway (Statistics Norway, 2012a). Crews are increasingly multinational, both on Norwegian-registered ships and ships registered abroad. As in the road sector, there are good reasons why increasing international participation would alter the accident risk profile in Norwegian shipping. Safety attitudes and safety experience have been found to be poorer for non-Norwegian crew and managers working for a large Norwegian shipping company (Håvold, 2005). Furthermore, ships registered in other lands are often able to operate under that country's wage and working conditions, which are often poorer than Norwegian equivalents, with clear implications for safety. Thus, the increase in the number of foreign ships running aground in Norwegian waters in the last decade may be due not only to the increased activity of foreign actors (Størkersen, Bye and Røyrvik, 2011) but also, partly, to their increased accident risk.

## Methods

Calculations of transport accident risk are based on the number of accidents occurring over a given distance (e.g. per million vehicle km), or during a given period of time (e.g. in the last year). Calculating the risk for road transport, we use exposure data from the lorry surveys. The national lorry surveys have been conducted continuously by Statistics Norway since 1993. The survey measures transport performance of a sample of Norwegian-registered trucks with maximum payload higher than 3.5 tons. During the reporting period each driver included in the sample has to register all trips and shipments performed during the period. The national lorry survey is conducted according to the Eurostat's statistics directive, which means that similar surveys are conducted in each member state. Statistics Norway gets information from Eurostat about trips that are reported to, from or within Norway in the surveys in other EU countries.

Calculating the risk for sea transport, we use the quarterly port statistics conducted by Statistics Norway, which cover information about number of calls for each port with more than one million tons of goods loaded and unloaded each year (about 30 ports). The port statistics cover information about number of calls, tons loaded and unloaded, commodity, and flag state divided into domestic and foreign flows. In the last two years the National Coastal Administration has established statistics that include information about sailing patterns for every ship movement on the basis of AIS (Automatic Identification System). In this project, we will try to combine AIS data with the port statistics to establish OD-matrices for sea transport along the Norwegian coast. Also for sea transport, route choice will be estimated by using the network module in the national freight-transport model for Norway.

These data are combined with accident data from national databases. Road accident data are based on the National Road Databank, which includes data on the nationality of vehicles involved in accidents. Sea accident data are based on the Norwegian Maritime Directorate's national register of accidents at sea. Both databases include the geographical locations of the accidents. Our study analyses the numbers of accidents involving foreign actors at geographical locations in Norway, in light of the numbers of foreign actors using the respective routes. This is compared with the number of domestic accidents and actors on the same route.

*Keywords: Accident risk, transport safety, foreign hauliers, cabotage, maritime transport, flags of convenience, safety culture*



# TECHNICAL SESSIONS TS4–TS6

Wednesday 01 October, 15.45–17.15

## Technical Session 4: Sector case studies: construction

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### 1. ‘When things go right’ – what can we learn from the safe construction of the London 2012 Olympic Park?

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Patrick Waterson, Helen Bolt, Roger Haslam, Alistair Gibb – Loughborough University, UK

Despite significant reductions in the number and rate of injury within construction in the UK over the last 20 years, it still remains a high-risk industry. A recent report from the Health and Safety Executive (HSE, 2013) found that construction accounts for 27% of fatal injuries to employees and 10% of all reported major injuries. Furthermore, an estimated 1.4 million working days were lost in 2011/12 – 818,000 due to ill health and 584,000 due to workplace injury (Labour Force Survey, 2012). By contrast, the accident frequency rate on the 2012 Olympic Park site was 0.16 per 100,000 hours worked – considerably less than the building industry average of 0.55, and less than the all-industry average of 0.21. In addition, there were no work-related fatalities on the whole London 2012 construction programme (HSE, 2012a). By any standards, this represents an enormous achievement of the overall project, particularly in light of the high failure rates of many recent large-scale government-supported projects (King and Crewe, 2013).

In our paper, we describe some of the key factors that contributed to this construction safety success story. Our work is based on a project funded by the HSE and published in 2012 (HSE, 2012b), and draws on evidence gathered from the following: a set of observations carried out between 2009–12, which tracked construction across six different London 2012 venues and infrastructure projects; a set of 17 interviews with project groups and senior managers/executives; document analysis of micro-reports and major reports (174 documents in total); and, feedback we received from the Olympic Delivery Authority and HSE as a result of presenting our findings.

The findings point to a set of systemic and people-centred factors, which, in combination, acted to ensure safe working practices across the site. These include: shared respect and trust among workers, supervisors and management (e.g. workforce involvement in decision-making, ‘keep in touch’ meetings); a clear purpose and alignment between strategic and operational day-to-day goals (e.g. balancing good communication across the site); and a safety culture that embodied transparency and openness. In order to position our findings in a wider context, we developed a systems-based model of the relationships between individual, team, and strategic and wider organisational factor components of the construction project as a whole. The model draws on previous work in human factors and ergonomics (Karsh *et al*, 2014), safety science (Rasmussen, 1997) and construction safety (Haslam *et al*, 2006). The systems model also helped us identify a number of ‘virtuous circles’ or complex chains of events, which reinforce one another through feedback loops (Schlesinger and Heskett, 1991). An example from London 2012 is the relationship between high levels of worker engagement in decision-making, leadership behaviours (e.g. high levels of respect and trust), and clarity of communication. These factors, in combination, span a number of levels of the overall system (managers, external combination to support high levels of

health and safety across the Olympic Park site. We devote part of our paper to describing these types of inter-relationships, feedback loops, and their outcomes in order to extract more generic transferrable lessons for the constructions industry as a whole.

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## 2. Management of emerging accident risks in the building and construction industry

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**Eirik Albrechtsen, Jan Hovden** – Norwegian University of Science and Technology (NTNU), Norway

A building and construction company experienced a number of unusual, unexpected fatal accidents related to collapses of scaffolding, prefab constructions, etc. These accidents were quite different from 'normal', common occupational accidents at worksites. The safety performance of the company and their procedures and practice in health and safety management were in line with standards and national best practice in this industry, but they had not been able to cope with these emerging (major) complex accidents.

Owing to the emerging accidents a team of researchers was asked to examine the company's safety management systems and evaluate its practices by using viewpoints and experiences from significant actors in their building and construction projects. Group interviews were performed at ten projects and at three administrative departments (projecting, purchasing and HSE&Q). This paper discusses the main results of the study related to safety management of complex major accidents. In particular, the paper focuses on how to manage complex major-accident risks compared with occupational accident risks, related to tools and methods, as well as organisational structures and practices.

The building and construction industry has been through great changes over the last 10-20 years with increased competition on costs and time, and new ways of organising, work processes, materials and technologies, resulting in rather fragmented patterns of contractors, subcontractors, sub-subcontractors, supply and suppliers from many countries within each building and construction project. This gives the context for emerging accident risks in the industry and the company studied, and a hint on relevant theoretical frameworks for data collection and analyses. We applied organisational diagnoses related to information flow, communication, relations, interactions, interfaces between groups of actors, distributed decision-making, and conflicting objectives. Problems related to deviation control, quality assurance, and barrier functions were also emphasised in the study.

## Main findings

The emerging accident risks were, to a large extent, attributed to deficiencies and deviations in input from other organisational units. Projects/production were blaming projecting and purchasing, and they were blaming each other and the top management of the enterprise and the builder. There were examples of cascade effects, starting with architect drawings that were not buildable; construction start-up before proper project plans were available; and delays due to projecting and purchasing waiting for detailed input from each other. All these problems in early phases help accumulate emerging accidents, which manifest in the construction phase.

These emerging risks are not closely related to traditional health and safety management. They are more connected to quality assurance, coordination and communication problems within organisational units but, mostly, in the interface between organisational units of the projects.

The traditional safety-performance indicators (LTI rates, etc.) do not reveal emerging complex accident risks. The HAZID checklists used need to be tailored to the hazards of each specific project in the enterprise. As a supplement, we propose developing proactive indicators of symptoms or signs of increased emerging accident risks in order to make the organisation prepared for adequate countermeasures before a disaster happens.

## Discussion and conclusion

These findings are discussed in relation to relevant theories and related safety research articles. We limit the discussion to safety problems the company itself can do something about, e.g. excluding the external stressors related to economy and market, competition and globalisation, the regulations, and the builder buying the building or construction. Of course, they can and should avoid some builders if contract conditions are unacceptable for safety reasons.

Fragmentation of tasks and responsibilities at all levels was a main problem. Example: Parts of the projecting were outsourced to a consultant in Sweden; projecting and building in parallel; steel beams were produced at Kola; precast concrete units came from a factory in Poland; and site workers came from the Baltic countries, Poland and Norway. On site, it was attempted to solve some of the communication problems by using homogeneous work groups working in parallel or at different phases of the construction process. There was an awareness of problems related to the flow of information and distributed decision-making, and that the formal safety management systems for compliance did not fully solve the problems.

These problems are discussed using organisational theory regarding co-ordination mechanisms vertically and horizontally – formalising through policy, rules and procedures; clear responsibilities; span of control; and standardisation of processes, input and output. We discuss supplementing means such as competence for: purchasing goods and services; all levels: management; technologists in different disciplines; and skilled workers. Improvements in magnitude and quality of the flow of informal information are emphasised in the paper.

The paper discusses and evaluates the safety methods and tools that are applied in the company, and suggests some supplementary indicators for revealing emerging complex accident risks in a systematic way.

*Keywords: Construction, occupational accidents, major accidents, complexity, communication, safety management*

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### 3. Safety by design in Danish construction

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**Casper Siebken Schultz, Kirsten Jørgensen** – DTU Management Engineering,  
Technical University of Denmark, Denmark

Occupational health and safety (OHS) issues are a topic of continuous interest in the construction industry. Serious accidents, fatalities and occupational illness are still, unfortunately, a major element of civil engineering and construction projects despite initiatives to reduce the number and seriousness of injuries and health-related impacts, as well as strengthened legal frameworks. In 1991, a report from the European Foundation for Improvement and Human Rights ('From Drawing Board to Building Site') documented that a third of the relatively large number of serious accidents in the construction industry was due to deficiencies in the design and project planning of the client and the client's consultants. Initiatives to enhance OHS in the construction industry, however, often direct the attention towards the execution phase.

An ongoing Danish research project investigates the inclusion of health and safety considerations in the design and project planning of civil engineering and construction projects as a means to achieve a higher level of health and safety in execution. The hypothesis is that health and safety problems in execution can be prevented through better planning in the early stages of the processes, and that accidents are prevented by providing safety. Two architectural firms and two consulting engineering firms are active research-project participants.

The research is divided into two coherent stages. In the first part of the research project a theoretical framework is developed from a combination of existing literature on health and safety and a mapping of existing practices based on semi-structured interviews in all four companies. Some 23 architects and engineers were interviewed and discussion was made with a reference group consisting of members from the four companies. The findings reveal that the basic knowledge on OHS among architects and engineers is limited and that OHS activities are often detached from the core activities in design and project planning. This highlights the need to strengthen OHS knowledge and competencies among OHS non-professionals and the demand for a structured and systematic approach to OHS in design and project planning. The investigation further emphasises that new OHS activities emanating from the research project must be integrated with existing design and engineering practices. The theoretical framework that was developed subsequently couples OHS risks in construction (safety, health and mental health) with the stages in the design and engineering processes, and is presented in two guides directed specifically at managers and designer/engineers, respectively. Moreover, these guides are supplemented by two explanatory manuals: one elaborating specific OHS risk, and another presenting cases of decisions in design and project planning with (good or bad) impact on execution processes.

The second part of the project is ongoing and tests the framework and material through interventions on three to four construction projects, followed by an evaluation of the results and processes. The intervention on the projects consists of workshops, interviews and interactions with participants in design and project planning – mainly architects and engineers. The intervention projects are to be executed successively through the fall of 2014. Currently, research interventions are executed on three projects: 1) the renovation of a public railway and station; 2) a new building in the form of a healthcare centre; and 3) the construction of a public school, including both renovation and new buildings. The presentation at the conference will document the current findings from the intervention projects.

The research contributes a practical framework and highlights the importance of implementing OHS considerations in planning and design, as the research investigates the effects in execution of an intervention process in design and planning.

*Keywords: Construction, design and build, health and safety, interventions*

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## 4. Participatory and directive safety management related to safety behaviour in the Scandinavian construction industry

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### Introduction

The construction industry is burdened with high accident rates. In 2007, 4.8% of the European construction workers reported one or more accidental injuries (Eurostat, 2010). Occupational safety has traditionally been managed through the implementation of rules and physical barriers (Hudson, 2007). Owing to an insufficient decrease in accident rates, this approach has been supplemented, in recent decades, by psychological approaches to occupational safety management (Glendon, Clarke, and McKenna, 2006). A recent meta-analysis of occupational safety categorises the factors predicting accidents into situation-related and worker-related factors (Christian, Bradley, Wallace, and Burke, 2009). Overall, the safety literature concludes that worker behaviour, leadership behaviour, as well as structural factors, influence safety performance and safety outcomes (Bahn, 2012; Barling, Loughlin, and Kelloway, 2002; Clarke, 2013; Griffin and Hu, 2013; Hoffmeister *et al*, 2014; Neal and Griffin, 2006; Zohar, 2000, 2010). In order to substantially improve safety in construction, it therefore seems essential to better understand the influence of such factors on safety.

Similarities between Sweden and Denmark include common historical background, similar social welfare systems, wage equalities, and trade unionism (Dyrehborg, 2011; Schramm-Nielsen, Lawrence, and Sivesind, 2004). In international research on cultural differences between nations, Sweden and Denmark are regularly grouped together in a cluster with other Scandinavian countries (Hofstede, 1984; House, Hanges, Javidan, Dorfman, and Gupta, 2004; Inglehart and Baker, 2000). Cross-cultural research states that the countries of Scandinavia are characterised by high levels of future orientation, gender egalitarianism, institutional collectivism, and uncertainty avoidance, as well as low levels of power distance and in-group collectivism (Chhokar, Brodbeck, and House, 2012; House *et al*, 2004).

Regarding Sweden and Denmark, as part of the same cultural cluster, one would expect to find similarities also concerning important organisational factors, such as occupational safety. Surprisingly, however, the number of fatal occupational accidents in the Danish construction industry is 33% higher than in the Swedish (Tómasson *et al*, 2011) industry. On the Öresund Bridge and Tunnel Project, as many as four times more accidents were measured among the Danish compared with the Swedish constructions workers (Spangenberg *et al*, 2003).

A qualitative cross-cultural study, contrasting two similar cultures, offers the possibility to develop the knowledge of phenomena affecting safety performance in the construction industry. The aim of the present study was to conceptualise differences between the Swedish and Danish construction industries that may have an impact on safety outcome, based on the experience of workers and managers who have worked in both countries.

## Method and participants

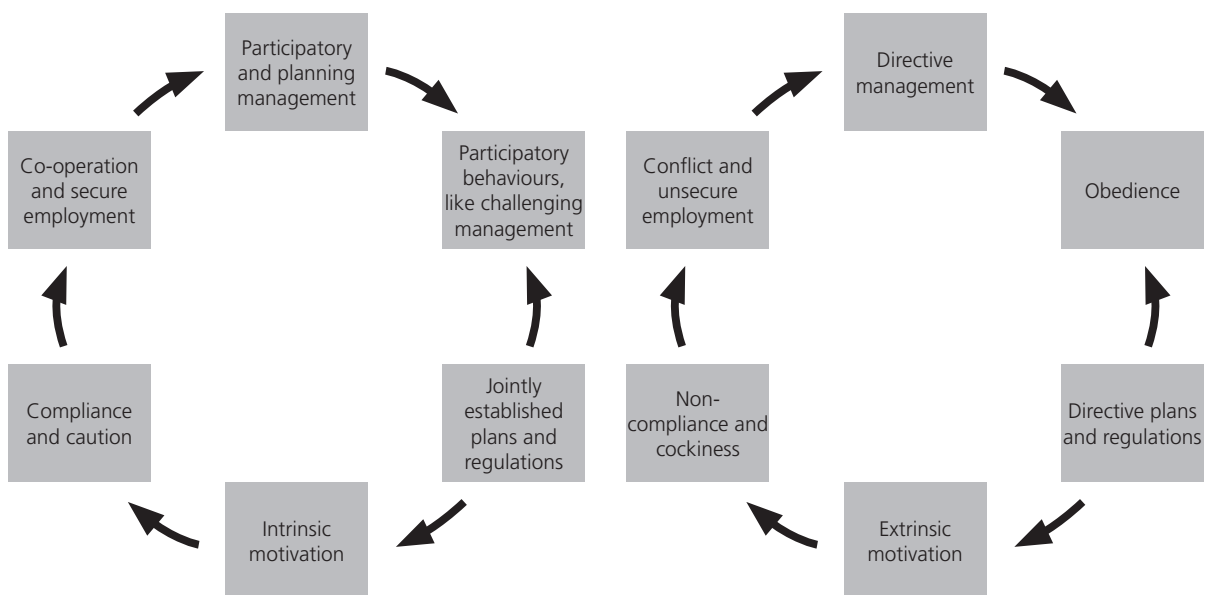
Nine informants, with experience of working in the construction industry in more than one Scandinavian country, were interviewed. Using the selection principle of maximal variation (Sandelowski, 1995), the accumulated experience of the informants covered: small, medium-size and large companies; different sizes of construction sites; different professions and trades; different age groups; both genders; and managerial and non-managerial positions. Four of the informants were Swedish: two workers and two managers. Five of the informants were Danish: two workers and three managers.

The interviews concerned perceived differences between Sweden and Denmark regarding structural and organisational factors, as well as leadership and workers' attitudes and behaviours, which may influence safety performance and safety outcomes. The interview guide was semi-structured and informed by previous research on factors anteceding safety performance and safety outcomes (Christian *et al*, 2009). The Danish informants were interviewed in Denmark by a Danish-speaking researcher and the Swedish informants were interviewed in Sweden by a Swedish-speaking researcher.

The approach to the analysis of the transcripts was largely inductive. The transcripts were analysed using semantic thematic analysis (Braun and Clarke, 2006; Frith and Gleeson, 2004).

## Results and discussion

Construction managers and workers described their experiences of safety management, safety performance and safety outcomes in the Swedish and Danish construction industries, revealing information concerning situation-related and worker-related factors (Christian *et al*, 2009). The descriptions were analysed and categorised into seven themes, revealing differences between Swedish



**Figure 1**

*A suggestion of how the themes identified in the present study may be interconnected to each other, and to intrinsic or extrinsic motivation, in circular functional processes. The participatory management circle to the left, illustrates the safety culture distinguished in the Swedish construction industry, and the directive management circle to the right, illustrates the safety culture distinguished in the Danish construction industry.*

and Danish safety culture in the following areas: participatory or directive management; defiance or obedience; compliance or non-compliance; cooperation or conflict; caution or cockiness; planning management; and employment security.

The findings regarding participatory or directive management related to compliance or non-compliance added nuance and complexity to previous findings concerning the interaction between safety management and workers' safety behaviours (Christian *et al*, 2009; Clarke, 2013; Griffin and Hu, 2013; Neal and Griffin, 2006). The effect that directive safety management can have on safety compliance behaviour may be two-fold. Instructions enforced from above without participatory influence from below seem to result in unanchored directives and subordinates less likely to comply with rules and directives. Directive safety management is also explained to augment safety performance when management communicates clear expectations and delivers reliable consequences.

To enhance safety participation behaviour, which involves workers taking a wider responsibility for safety, challenging management when needed, and voicing own suggestions for safety improvements, participatory management is necessary. Participatory management may be used as a way to anchor rules, regulations and plans. The finding that participatory management may have a positive impact on safety performance in the construction industry is also supported by previous research (Shannon *et al*, 1997; Törner, 2011).

To conclude, the informants' qualitative descriptions contribute to a more nuanced understanding of factors underlying differences in accident rates between the Swedish and Danish construction industries, and highlight important safety cultural aspects. The results may be used to guide practitioners working on decreasing the accident rates in the construction industry.

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## 5. How to learn and avoid accidents? The case of a collapse in airport building construction

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The collapse of a building during its construction is not a good perspective for safety and occupational health. Traditionally, accident analyses are restricted only to the analysis of immediate causes and not the latent ones. The latent causes are usually 'invisible', and they are related to managerial and organisational origins. When they become known, it opens the possibility of taking more effective actions toward avoiding future accidents.



This project aims at analysing a collapse that occurred during the construction of a new airport terminal in Brazil and helping actors learn and reformulate the activity system of construction to avoid new events. The event is analysed using a model of analysis and prevention of accidents (MAPA). This model aims at understanding the latent causes in relation to how the activity system works. The MAPA is divided in six main steps: normal work analysis without accident, change analysis, barriers analysis, managerial and organisational analysis, conclusions, and recommendations.

The data is based on: a) interviews with people involved directly or indirectly in the accident (workers involved or those not in the accident, managers, engineers and architects); b) observations to understand the normal work; and c) analysis of safety documents. To create new solutions, the collected ethnographic data and the data about the accident will support the sessions of an intervention using a method called the Change Laboratory. The intervention will involve actors to understand the basic contradictions in the activity system and to create new solutions so that events like the collapse of a building can be avoided. The Change Laboratory is a methodology developed by the Center for Research on Activity, Development and Learning (CRADLE – University of Helsinki) and is based on the Cultural-Historical Activity Theory (CHAT). The method stimulates the following learning actions: a) questioning critical aspects of existing knowledge and practices; b) a historical analysis of the situation and current empirical analysis explaining the problems; c) designing new solutions; and d) testing and applying the new solutions to enable a new form of stable activity.

### **Preliminary results**

The airport building construction collapsed at night during one of the processes of concrete placement. The second floor fell down and 14 workers were injured. The Police Technique Institute's analysis report showed that the building that was being constructed differed from its blueprints. These differences can be classified into: new type, discrepant, and non-execution of work designed. This report does not explain some managerial causes connected to the accident. A preliminary analysis shows that such a large-scale project has been accomplished by outsourcing, but with a weak supervision process that can lead to work accidents. The different subcontracted companies have their blueprints and sometimes these projects are different from the main contractor's projects. In situations of conflict, the workers do not know which blueprint they have to follow. It could be explained by different projects on the construction site and having many documents for the workers to follow. Moreover, there is a reduced staff for conducting some functions, which leads to intensive workloads with extra working hours. There is also a time pressure during the construction for the workers to do their job faster, which reduces the safety on the construction site. There are delays in the delivery of materials that impact the overall construction schedule. On the day of the accident, the concrete material delivery was delayed and the morning shift workers had to wait before installing it later that night. The safety management's team was not integrated into the strategic management of the building. Based on this, it is possible to hypothesise many latent causes (managerial and organisational) and contradictions, which may be related to the accident. There are organisational problems between the main contractor and the subcontracted companies.

The Change Laboratory, as a systematic learning process, may help to understand and change the construction activity system. In this method, the unit of analysis is an activity system, and not an individual actor. In this system, it is assumed that the relationship between the subject and the object is mediated by cultural artefacts, as well as social mediators: rules, community and division of labour. In the specific case, the activity system involves a large number of workers from many different companies. The main contractor is considered the subject and has responsibility for the construction of the new terminal building, which is the object. The rules and regulations are delivered by the government, and there are some tools to mediate, such as the subcontracts and management follow-up systems. The community for this activity system can be the designers, architects, engineers, for instance. The division of labour is composed of the subcontractors, and all subcontractors have their own activity systems.

This study is ongoing and the results presented are preliminary, only reflecting the current stage of the study. At the moment, an in-depth investigation and analysis are being conducted involving the different actors to understand this accident, its contradictions, and the activity system.

*The project is supported by Research Foundation of São Paulo State (FAPESP 2012-04721-1).*

*Keywords: Learning from research for practice, prevention of accidents, airport building construction, model of analysis and prevention of accidents, change laboratory*

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## 6. A tower-crane accident analysis by the Dutch Safety Board: is it a 'normal' accident?

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Tower cranes are complex and impressive installations. They constitute critical aspects of safety at construction sites and make them inherently dangerous. 'Crane instability', 'jib instability' and 'hoisting equipment instability' used to be main accident scenarios. Because of the crane's technical quality, nowadays these scenarios occur less frequently. Load instability is now a dominant scenario.

A few years ago, a tower crane collapsed in Rotterdam, seemingly without cause. The Dutch Safety Board extensively investigated this accident, questioning whether the accident was a so-called 'normal accident' in Perrow's terms. Prior to assessing the impact of management and organisational factors, accident analysis should first start with an analysis of the actual accident process.

The results show a much greater flexibility of the jib than that calculated by the design engineer. Together with an incorrect parameter setting of the trolley motor, the load moved in an uncontrollable fashion over the jib and the crane collapsed. The defects in the design of the crane were not identified, and the crane acted like a complex, tightly coupled system with a very limited failure recovery time. Therefore, the accident was classified as a 'normal accident': one that was essentially integral to the design and could also thus occur in other tower cranes of the same make.

These design shortcomings emerge as process disturbances once the crane is operational. Nevertheless, the collapsed crane did have a CE mark. Other officially required safety audits and crane inspections did not address possible defects in the design, production or operation of the crane. Once on the market there appears to be no further effective safety net for the detection of structural weaknesses.

# Technical Session 5: Sector case studies: power generation

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## 1. The development of a safe standard operating procedure in the Chinese power transmission and distribution industry

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In most situations in the Chinese power transmission and distribution (PTAD) industry, unsafe actions of front-line workers have been regarded as the main contributor of accidents. Studies have shown that the front-line workers were poor at risk identification because of passiveness and lack of tailored procedures.

A standard operating procedure (SOP) is a set of written instructions that describes a routine or repetitive activity prescribed by the organisation. Job safety analysis (JSA) is an efficient proactive measure for safety risk assessment. In order to encourage front-line workers to take part in the process of risk management and develop tailored safety procedures for different jobs in the PTAD industry, the current study adopted SOP and JSA approaches to develop a structured method for hazard identification, risk evaluation, and hazard control for front-line workers for each step in their jobs; this method is called a safe standard operating procedure (SSOP). Firstly, for hazard identification, a PTAD industry-hazard checklist was compiled consisting of three components: hazardous elements, initiating mechanisms and targets/threats. Thereupon, the front-line workers were requested to describe the common hazard scenarios one by one, in each step of their job, using the checklist. Secondly, for risk evaluation, a job risk-assessment metric was used based on previous research. The front-line workers then made risk evaluations for each hazard scenario before and after countermeasures were taken, respectively. Reductions of risk level for each scenario, each job step, and each job were visualised through a spider chart. Thirdly, regarding hazard control, the SSOP involved countermeasures at four levels of hazard control: organisation, project, work team, and personal.

The SSOP method was then applied at the Taiyuan Branch of the Shanxi Electric Power Company. After several trial rounds of discussion about the applicability and reliability of the hazard checklist and the risk metric among the research team members, the safety engineers and technical engineers, the method was introduced to, and implemented with, the front-line workers and their work teams at six main areas of the company. In total, 146 different jobs were selected and each job step was analysed; every hazard scenario was identified, evaluated and provided with control measures and re-evaluated by research team members, managers and front-line workers. Then, the tailored SSOPs for the 146 jobs were built. In total, 1048 hazard scenarios were identified and the reduction of risk in each scenario, step and the whole job was depicted via a spider chart. The result showed risk associated with most scenarios and jobs could be reduced to an acceptable level even after taking simple countermeasures at a personal level. Moreover, some changes relating to safety management issues were initiated in the organisation:

- hazards were identified systematically rather than according to the engineers' feelings, and front-line workers were actively involved in the process;
- workers and managers now clearly realise the risks in each step of their jobs using the risk metric, and the expected reduction of risk visualised by the spider charts, which were only blurred concepts before;
- hazard-control countermeasures were identified by the front-line workers and the managers instead of being provided by the engineers or safety professionals. These countermeasures were clearer and simpler for the front-line workers to implement than before; and
- risk management in the organisation was changed from a reactive style to an active one, and front-line workers changed from simply rule-followers to rule-makers.

*Keywords: Safe standard operating procedures (SSOP), standard operating procedures (SOP), job safety analysis (JSA), power transmission and distribution (PTAD), hazard scenario*

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## 2. Why are workers dying in the Brazilian electrical sector?

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### Introduction

From 2003 to 2012, 750 deaths were reported as workplace accidents in the Brazilian electrical sector. In 2011, the mortality rate in the sector was 31.9 per 100,000, 5.5 times higher than the rate in the formal sector. Most of these accidents occur in maintenance activities in the electrical-energy distribution network, generally composed of conventional and unprotected overhead lines ('live wires'). In more modern electrical systems, other network modalities predominate, such as: compact; those isolated with sheltered conductors; or even underground networks operating with fewer risks of contact.

### Objective

This study presents analyses of three workplace accidents that occurred in the state of São Paulo: two fatal and one with serious injuries, affecting electricians providing maintenance of energy distribution networks. The analyses aim to comprehend these events in depth, and supply an elaboration of prevention strategies.

### Method

We used the model of analysis and prevention of workplace accidents (MAPA), a conceptual and technical guide for the collection and interpretation of data. We aimed to identify the greatest possible quantity of information related to accidents approached as social-technical phenomena with origins in aspects of the history of the distribution system, in particular, managerial and organisational workplace choices. The study involves: interviews with the accident victims or their colleagues; observation in workplace locations; analysis of documents related to the history of the system and of the accident, such as reports of investigations completed by the safety team of the companies; internal safety norms; and training programmes, etc. Approaches supported in MAPA are opposed to those that explain accidents as individual phenomena, resulting from failures of the operator or his or her colleagues.

### Results

**Case 1:** An accident during replacement of a cross-beam of the 13.8 kV 'primary line' of the distribution network. The task was performed by two teams, each comprising a pair of electricians. The vehicles are

equipped with a single mobile basket that is elevated up to the network by a hydraulic system installed in a Munck-type truck, with one operator in the basket and the other on the ground. The pre-task safety measures include: signalisation of the area and partial coverage of the network with insulation to avoid contacts with the energised line. The insulating blanket used had an approximate width of 15cm and length of 30cm. The wooden cross-beam that should have replaced the damaged one arrived with drill holes of measures different from those of the piece to be replaced, requiring new drilling and prolonging the task. The electricians were positioned on opposite sides of the basket acting as two distinct teams, which had never worked together. During the intervention the hand of one worker touched the unprotected energised structure, resulting in electrical shock and death.

**Case 2:** The task of opening the transformer circuit-breaker keys to de-energise the secondary line (127/220 and 440 Volts) was performed by two workers, one of whom was on a ladder joined to the transformer post while the other was on the ground. While examining the transformer, elevating his body to see the upper part of the equipment, the worker drew his upper limbs close to the primary network (13.8kV), which permitted the formation of a voltaic arc that struck him. The current entered the right wrist dorsally and exited through the left foot of the victim, who lost consciousness and fell, becoming trapped by the safety belt and lanyard. Although aided by rescue workers, he succumbed to his wounds and died at the health centre.

**Case 3:** While one worker used a chainsaw to cut eucalyptus situated near a transmission line of 138kV, his colleague underpinned the same tree with a wooden log. Suddenly, the tree was knocked over by a strong wind and fell over an energised line. The accident victim suffered shock and severe burns while attempting to contain the fall of the eucalyptus to protect himself. The tree conducted an electrical current.

## Discussion

The cases described illustrate situations in which real work transpired with or without an insufficiency of barriers for protection and prevention against electrical risks already well known and addressed in the safety norms established in the country. In all the cases, small changes in activity can lead to an accident, since the functioning of the system depends on the non-interruption of the energy supply to the population, which, in turn, encourages use of work permits in proximity to energised lines. ANEEL, the national regulatory agency of the system adopts a reduction of the time that the energy supply is interrupted as an indicator of the efficiency of concessionaires. If these goals are not achieved in this regard, the companies incur fines or other punishments. The regulatory agency has also adopted a reduction in the costs of maintaining the electrical network as an indicator of efficiency, thereby encouraging outsourcing practices associated with precarious conditions and labour relations in the sector, including those related to the management of safety and health in the workplace. The conduct of this process in the Brazilian electrical sector takes place under the aegis of the logic of strict defence of economic interests. The fact that the safety performance of concessionaires and their contractors has shown a significant increase in fatal accidents in the same period tends to be treated as a negative externality of no interest to the system. This study shows evidence that the current incentives for outsourcing in the Brazilian electrical sector may be a cause of its worsening health and safety indicators – in particular, via the introduction of steps that weaken the scope of prevention measures against electricity risks enshrined in the country's laws, especially by incentivising work permits in proximity to 'live wires', and also by the opening of work to companies that show an inability to adequately apply the safety measures recommended for the sector. The study also indicates the need for organisational and social changes in the system with an incentive for technological modernisation, and investments in improvements in reliability, the valuing of work, and prevention.

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*Keywords: Accident analysis, accident prevention, organisational analysis, electrical sector*

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### 3. Interactions between ‘human’ and ‘non-human’ actors for a collaborative health and safety inspection process and their application to civilian nuclear power

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#### Background

Occupational health and safety is on the corporate agenda. There are many challenges and no lack of attempts to reduce the vulnerability of organisations faced with occupational accidents or illness. Of these, the inspection takes pride of place. Classically, it aims to assess the state of a system with respect to a given repository, whether a regulatory framework (e.g. the French Labour Code), an international standard (e.g. OHSAS 18001), or internally (e.g. a company's good practice guides). The inspection concerns an organisation (a business sector, a site, a service, or workshop within a business, etc.) and all its various aspects (activities, processes, skills or software). Numerous actors are involved in inspections and each has their own status, procedures and aims. The inspection may be external (carried out by government departments, control or advisory boards) and/or internal (audits implemented by senior management and self-evaluations carried out by a site or service seeking continuous development).

‘Human’ actors are not the only ones involved in the inspection process. The considerable progress made in information and communication technology has led to the emergence of ‘non-human’ actors that take the form of databases, decision-support software, and, more recently, with the development of the internet, services with high added value. The ‘system of actors’ is therefore both broad and complex. The relationships and interactions between human actors, ‘non-human’ actors, and humans and non-humans merit analysis.

This paper examines inspections in the civilian nuclear industry, specifically those related to the exposure of employees to radiation. In general, nuclear power is characterised by stringent safety and security requirements, especially in regard to on-site workers, as radiation exposure is a major health risk.

#### Originality

The originality of our work lies in the fine-grained study of the interactions between the actors involved in inspections. It looks at a broad range of ‘external’ and/or ‘internal’ stakeholders, who are both ‘real’ (i.e. human) and/or ‘virtual’ (i.e. non-human). Our results take the form of a series of models that describe the actors, and their activities and interactions, together with the collaborative approaches they implement – whether voluntarily or not (legal obligations, implementation deadlines, resources, and available means, etc). These models are used to assess the compliance of a system with one or more repositories and, consequently, to co-construct a continuous development process. The models are implemented in a practical context in an experiment with a partner company that utilises expertise and skills via a collaborative software platform.

#### Methodology

Our work is based on the body of French health and safety legislation, together with regulations specific to the nuclear industry. We draw upon two theories from the field of sociology. The ‘actor-network’ theory focuses on the interactions between the actors in a system and how they work together. This theory assumes equality between all actors (human and non-human). It defines the relationships of the actors in a network by the translation that each one makes of its objectives and those of others, and uses them to analyse their influence on each other. Actors can arrange themselves into ‘macro-actors’. The question is therefore to define the core actors that make it possible to identify the network(s) under

examination. In our experiment, the network of actors involved in the inspection mainly consists of three types of macro-actors: the inspectors, the inspected, and information systems.

On the other hand, the theory of social regulation examines regulatory phenomena. There are two types: control regulations that are applied by supervisors or institutions, and autonomous regulation that governs those who must respect the rules. The meeting of these two types of regulation gives rise to new rules through a process of negotiation. This leads to joint regulation through agreements (compromises, contracts, undertakings, etc). An analysis of control regulations that are applied during an inspection makes it possible to understand the role of inspectors and how they operate. Autonomous regulation relates to those who are inspected and the extent to which their room for manoeuvre is compatible with the demands of inspectors. Information systems play a role in discussions and negotiations as engineering tools for knowledge sharing.

These two theories make it possible to propose an objective analysis of the system of actors and the various regulations with which they work. The theoretical foundations are augmented by field surveys that make it possible to specify and validate the models we develop. The fact that the experiment was carried out with a partner company made it possible to check, based on data from a specific case, the contribution of information systems to a collaborative approach to inspections. It raises questions about data sharing, the use of data and their limitations, through a field survey that combines documentary research, individual interviews, and questionnaires.

*Keywords: Safety management, inspection, control, Actor-Network theory, nuclear, social regulation theory, occupational health and safety*

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## 4. Managing safety culture in design activities: evidence from the Nordic nuclear power domain

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**Nadezhda Gotcheva**, Pia Oedewald – VTT Technical Research Centre of Finland, Finland; **Luigi Macchi** – DEDALE, France; **Håkan Alm** – Luleå Technical University, Sweden; **Anna-Lisa Osvalder** – Chalmers University of Technology, Sweden; **Mikael Wahlström** – VTT Technical Research Centre of Finland, Finland

### Background

Design flaws are one contributing factor to major industrial accidents. However, design activities and design organisations are still a fairly under-studied subject in human and organisational factors or safety culture studies. In the nuclear power domain, designing of the plant modernisations and modifications



usually requires collaboration of a network of organisations and stakeholders to develop solutions, which meet a wide range of criteria and requirements. In many cases, design work is outsourced by nuclear power companies to design organisations, which might not be hitherto familiar with the nuclear industry context and regulations, and its specific safety requirements. It is unclear what organisational challenges are associated with design activities in a networked context, and how they affect the safety and resilience of operating nuclear power plants.

## Objectives

The current study aims at providing insights into the inter-organisational challenges related to design activities, which might potentially affect the safety of Nordic nuclear power plants. This includes understanding inter-organisational and cultural challenges for achieving good quality design in nuclear industry projects, as well as how these challenges have manifested in actual projects and how the organisations cope with them.

## Methods

The current study is based on 19 in-depth interviews conducted between 2012 and 2013 in Finland and Sweden, and two group interviews. The interviewees were representatives of nuclear power-plant organisations, design organisations, and regulators. The interviews were transcribed, translated and analysed from safety culture and resilience-engineering perspectives. The results were discussed during multiple researchers' workshops and further discussed and validated in a workshop with power companies and regulators.

## Results

The study identified five macro challenges related to design activities within the Nordic nuclear power context: 1) safety is not always the first and most important guiding value in the design process; 2) understanding the context in which the designed end-product will be utilised may be difficult for the designers and this may lead to dysfunctional designs; 3) organisations do not always share the same safety philosophies and understand safety requirements in the same way; 4) coordinating activities may be difficult between organisations that work according to different logics and understandings; and 5) distributing responsibilities and balancing roles between different stakeholders. Furthermore, associated coping strategies or opportunities were identified.

## Conclusions

One of the main conclusions of this study was that challenges in the design processes in the nuclear domain are mainly inter-organisational. Thus, the safety management and safety culture approaches should take better account of the inter-organisational nature of the work processes. Overall, the study revealed that for some of the challenges (e.g. coordination) plenty of coping practices exist throughout the network. This indicates that organisations involved in the design processes have learned the consequences of insufficient coordination in previous projects and, based on this experience, actively developed ways for dealing with them. However, for other challenges (e.g. shared understanding) just a few coping strategies were mentioned, which signifies that their importance was not fully recognised by the different organisations involved in the design processes, or that it is more difficult to deal with them. The study implies that identification and understanding of these challenges could contribute to anticipation of emerging risks linked to new designs and overall better safety management. The design process involves both rational and creative approaches to a real-life problem. To develop safe and functional design in the nuclear power domain, designers need to find a balance between innovation and fulfilling specific requirements and paperwork. Thus, to better manage safety culture in design activities in a networked context, the nuclear power companies and the relevant design supply chains need to develop a shared acknowledgement on this dual perspective.

*Keywords: Safety culture, design, nuclear power industry, organisational challenges, networks*



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## 5. Expected and experienced benefits of human performance tools in nuclear-power maintenance activities

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**Pia Oedewald** – VTT Technical Research Centre of Finland, Finland; **Ann Britt Skjerve** – Institute for Energy Technology (IFE), Norway; **Christer Axelsson** – Vattenfall, Sweden; **Kaupo Viitanen, Teemu Reiman** – VTT Technical Research Centre of Finland, Finland

### Introduction

In the nuclear industry, international peer networks have a strong influence on safety management practices. In recent years, most nuclear plants in Western countries have implemented so-called human-performance programmes. These are based on an idea that human errors are often major contributors to events in which nuclear safety is compromised and, thus, organisations should implement a systematic error-prevention approach. Human-performance programmes have mainly been developed by practitioners and disseminated through informal networks and international bodies. The programmes typically apply human-performance tools (HPTs) for preventing human errors and strengthening controls. HPTs are a mixed set of methods or principles that the employees are expected to apply. Some of the HPTs seem to have their origins in aviation error-management tradition (such as three-way communication); some are work practices widely applied in complex industrial tasks (e.g. pre-job briefing); some seem to be drawn from safety culture tradition (e.g. questioning attitude); and some have their roots in behaviour-based safety (e.g. task observation).

Despite the prominence of human-performance programmes, there is little scientific literature on their beneficial effects or the basic premises underlying them. An interesting question concerns their primary goal of reducing errors and strengthening controls. Throughout the last decade many safety scientists have argued that this strategy has limitations. When safety controls are too rigid, smooth execution of the work becomes complicated and the likelihood of ‘cutting corners’ increases. The resilience-engineering school claims that variations in the performance should not be totally eliminated since variability gives rise to flexibility and, thus, ability to cope with the unexpected. A focus on systems-level dynamics, rather than on errors of individuals, has been suggested. Despite theoretical developments, nuclear industry practitioners put substantial effort into implementing HPTs. Another question concerns employee acceptance of the HPTs. Research shows that behaviour-based safety programmes have not always been well received. Furthermore, there may be national culture differences that affect the attitudes towards the HPTs and, thus, their utilisation and benefits.

This paper reports findings from an ongoing study, which analyses the expected and experienced benefits of the human-performance programmes in nuclear power-plant maintenance activities. The research questions covered here are:

- what are the expected benefits of human-performance programmes and HPTs? and
- how do maintenance personnel perceive the application and effects of HPTs?

### Methods

In 2013, case studies were carried out in three Nordic nuclear power plants. In two of the case organisations a human performance programme was introduced some five years ago. In one plant they were planning to implement a human-performance programme, but some of the tools were being used already. Altogether 47 interviews were conducted, involving maintenance supervisors, technicians,

managers, and control-room operators. In two of the case organisations, a survey was also sent to the maintenance organisation.

Furthermore, an international survey was disseminated to human-performance experts around the world to gain more insight into the underlying motives, benefits and disadvantages of the programmes. In total, 135 responses from 47 organisations in 13 countries were received.

## Results

The results show that often the espoused goal of a human-performance programme is to prevent events (nuclear safety incidents) by preventing/catching human errors. The Nordic case organisations had not measured the impacts of the programmes. However, the interviews indicated that maintenance personnel associate many other benefits with the HPTs than reduced number of events. Smooth execution of work tasks and, thus, less rework and smaller occupational injury risk were often mentioned as practical benefits. In the interviews only a few examples of errors that directly compromise plant/nuclear safety were given. The tools were seen to affect safety indirectly by changing safety culture. The expected positive changes in culture included more rigorous ways of working, shared knowledge on tasks and their risks, improved organisational learning, and feeling that managers care for safety. The results show that the HPTs serve different functions. Some of them clearly aim at preventing active human errors, while others serve broader functions, e.g. coordination of schedules or sharing of lessons learned.

Maintenance personnel in the Nordic plants held fairly positive views on the HPTs. Newcomers, especially, perceived the HPTs as practical means to convey the organisational expectations on how work is done here. The way the HPTs were introduced was criticised more often. Many of the practices had been used at the Nordic plants for a long time and, thus, there were questions as to why they are now labelled as HPTs and promoted with a programme. Furthermore, a common opinion, both in the Nordic and international samples, was that extensive use of the HPTs requires time, which then shortens the time for the 'real work', delays some tasks, or reduces production. In many cases the implementation strategy had failed to determine clearly when and where each of the tools are necessary, and whether they can be tailored to situations. When the tools were required in simple and routine-like work they were often perceived as a nuisance rather than beneficial. Sometimes employees perceived a double standard: they were required to use a tool but there was no possibility to do so (e.g. not enough personnel to work in pairs).

The international survey results partially resonate with the scientists' concerns of error-focused safety management approaches. Observations that strong focus on the tools decreases the focus on tasks themselves and impair the workers' attention or judgement were reported. In the Nordic plants, HPTs were sometimes perceived as naïve and awkward. Some evidence of experienced shame and blame was reported as well. Thus, in order to gain positive impacts with HPTs, the implementation strategy and style are of crucial importance. The effect on national and organisational culture on the implementation style will be discussed.

*Keywords: Human error, safety management, nuclear safety*

# Technical Session 6: Learning from research

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## 1. Cultural readjustment after disasters: “purification rituals” as barriers to learning

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Stian Antonsen – SINTEF Technology and Society, Norway

The immediate phase in the aftermath of a major crisis or disaster bears some resemblance to Victor Turner’s concept of ‘liminality’. This concept refers to the transition phase an individual undergoes when passing from one phase or status to another that is characterised by ambiguity and disorientation. Major crises sometimes serve to shake the very foundations of the identity and norms of a group, organisation or society. For instance, in the days after the 9/11 attacks on the World Trade Center discussions flourished around the question of whether the US would ever be the same again. In American educational resources, 9/11 is described as “the day that changed America.”<sup>1</sup>

In this paper, we explore how responses to crises can be analysed as a form of ‘purification ritual’ and how this influences efforts to prevent disasters from repeating. This analysis is informed by perspectives from cultural anthropology. The study focuses on the ‘cultural readjustment’ phase of Barry Turner’s accident model. The relevance of this phase has been largely ignored by existing research on safety culture. We argue that this phase is important, as it strongly influences subsequent learning efforts.

The empirical basis for the paper is historical information on the aftermath of three disasters involving the Norwegian Government: the accident in the Kings Bay mines at Spitsbergen in 1962; the handling of the 2004 Tsunami in South East Asia; and the terror in Oslo on 22 July 2011. The results indicate that responsibility tends to become personified, even within ‘no-blame’ cultures. After major disruptive events, one of the key forms of cultural readjustments is to reinstate an image of security and control among stakeholders and the general public. This leads to the purification rituals through which individual managers or other stakeholders are made into culprits and sacrificed in order to symbolise that the system is readjusted and, thus, ‘fixed’. This mechanism, while not unimportant for the feeling of security for the actors involved, often involves a premature closing of the learning loop.

*Keywords: Disasters, learning, cultural readjustment*

### Reference

<sup>1</sup> [http://teacher.scholastic.com/scholasticnews/indepth/911/teachers/resources\\_changed.htm](http://teacher.scholastic.com/scholasticnews/indepth/911/teachers/resources_changed.htm)

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## 2. Assessing occupational risk in the Netherlands

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**Olga Aneziris** – NCSR ‘DEMOKRITOS’, Greece; **Linda Bellamy** – White Queen BV, Netherlands; **Ioannis Papazoglou** – NCSR ‘DEMOKRITOS’, Greece; **Martijn Mud** – RPS Advies BV, Netherlands; **Martin Damen** – RIGO, Netherlands; **Henk Jan Manuel** – National Institute for Public Health & Environment, Netherlands; **Joy Oh** – Ministry Social Affairs & Employment, Netherlands

A methodology and associated tools for supporting decisions relevant to the management of occupational risk have been developed in the ORCA (occupational risk calculator) project, performed on behalf of the Ministry of Social Affairs and Employment of the Netherlands. As part of the ORCA project, a list of 64 generic hazards related to various aspects of workers’ activities has been identified, and the risk to workers in the Dutch population from each of these hazards has been quantified. Quantification of risk requires, in general, two types of data: a) number of accidents; and b) exposure of working population to the corresponding hazard. The number of reported accidents has been assessed from the analysis of the database of the Dutch Labour Inspectorate (I-SZW), to which work-related serious accidents are reported under Dutch law. A survey of the Dutch working population has provided the total time the worker population, subject to the reportable system, has spent working in activities involving each of the 64 hazards.

Assuming that the occurrence of accidents follows a Poisson random process, the risk for each generic hazard has been assessed as a maximum likelihood approximation. Point estimates of the risks have been calculated using the average yearly exposure of the workers to each hazard. Risk has also been assessed for the following ten sectors: agriculture and forestry; construction; industry and mining; trade; hotels and restaurants; transportation and communication; financial institutions; public administration; education; and healthcare. A relative ranking of the 64 hazards on the basis of the risk of fatality, and recoverable and permanent injury per working hour is provided for the specific sectors and for the overall working population. Risk assessment across sectors permits the estimation of the most risky sectors for each hazard. For example, ‘fall from floor’ has the highest fatality risk in hotels and restaurants; ‘fall from fixed platforms’ in healthcare; ‘fall from height unprotected’ in the agricultural sector; and ‘fall from fixed ladder’ in the transportation and communication sector.

In addition, the most important hazards for each sector can be estimated. In the agricultural sector, the following hazards have the highest fatality risk: fall from placement ladder; fall from height while being unprotected; and struck by falling objects. In construction, impact by immersion in liquid, contact by falling object, and fall from roof have the highest fatality risk. Similar results have been obtained for all consequences (recoverable, permanent injury and fatality) for the ten sectors analysed. In practice, this permits the introduction of specific safety measures for the needs of each sector. For example, in the agricultural sector some important measures preventing fall from ladders are proper dimension and location of ladders; measures preventing fall from height when working without protection are the use of fall arrests and having free hands; and, finally, an important measure protecting from falling objects is demarcation of the dangerous zone. Therefore, the management of these measures, which consists of their use, inspection, maintenance and availability, is of great importance for workers of the agricultural sector. Similar conclusions may be drawn for all sectors analysed, and an overview will be presented in the paper.

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### 3. Health and safety in a changing world: an overview of the IOSH research programme

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#### Robert Dingwall – Dingwall Enterprises, UK

Since 2004, IOSH has been supporting a £1.4 million research programme with three objectives: to map OSH responses to changes in the industrial, political and social environment; to reconcile wealth creation with effective protection for workers, families and communities; and to define future role and skills of OSH practitioners. This is being carried out through six projects:

- The OSH knowledge base (Institute of Occupational Medicine), to define what this is, where it is stored, how it is accessed, and how it informs practice;
- The flow of OSH knowledge (Loughborough University), to investigate the local use of OSH knowledge, particularly in complex, networked organisations;
- The changing regulatory environment (University of Nottingham), to examine the shifting landscape of public and private regulatory interventions;
- SME engagement with OSH (Loughborough University), to examine OSH knowledge and practice in small, medium and micro-businesses;
- Practising safety leadership (Cranfield University), to examine the skills required for OSH practitioners to exercise leadership roles; and
- Changing legitimacy of health and safety at work (Universities of Reading, Portsmouth and Nottingham) to investigate the reasons for the growing criticism of OSH regulations by political and business interests since the 1960s.

This paper will give an overview of preliminary results from this programme, with particular reference to:

- the need to adapt OSH practice to work in more flexible organisational contexts, with a concern for business reputation management and creative problem-solving rather than, primarily, as an advisor on regulatory compliance;
- the need to focus more on the local context of OSH interventions and the engagement of workers through an understanding of human and social factors;
- the need for a more precise understanding of SMEs and micro-businesses rather than seeing them as smaller versions of larger organisations;
- the need to appreciate the extent to which OSH regulation in the UK is now related to the requirements of the single European market and contributes to creating the conditions for fair competition within that market; and
- the need for OSH practitioners and their representative bodies to engage more proactively in the management of social, organisational and political environments for their work, to ensure that its positive concern for employee wellbeing is not overshadowed by complaints about constraints on managerial autonomy.

Although not yet completed, the projects already show the importance of extending the traditional science base of OSH education and practice to include elements from the social sciences. These can give a basis for strategic thinking about public policy issues and for developing skills in leadership, team working, and interpersonal persuasion. The first contributes to a positive collective voice for OSH interests: it equips the profession to lead policy-thinking, rather than respond to less-informed ideas from other sources. The second equips practitioners to take on the more flexible roles needed by changing industrial processes and structures.

*Keywords: Knowledge, research into practice, education and training, regulation*

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## 4. Occupational safety and health research informing practice – the magnitude of work-related musculoskeletal disorders in therapists

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**Dervla Hogan** – University College Cork; **Sheilah Nolan** – University College Cork / Kerry Health and Safety; **Birgit Greiner** – University College Cork, Ireland

### Background

Work-related musculoskeletal disorders (WRMSDs) are one of the major health problems at Europe's workplaces, accounting for a large proportion of work-related injury, sickness absenteeism, and long-term illness. They can result in direct and indirect financial costs for the employer, such as increases in insurance premiums, decreased productivity; and, for the employee, such as loss of earnings. They can also result in a negative impact on the employee's quality of life, with workers in healthcare being one of the most affected groups. Chartered physiotherapists, physical therapists and athletic therapists form large groups within healthcare occupations. The current research, focused on WRMSDs in physiotherapists/physical therapists, indicates that injury or strain to the low back is the injury with the highest prevalence, followed by the wrists and hands. One of the most worrying findings of the existing literature is that the lifetime prevalence of WRMSDs among physiotherapists/physical therapists may be as high as 90%. The aim of this paper is to determine the prevalence of WRMSDs for chartered physiotherapists, physical therapists and athletic therapists in Ireland.

### Methods

The findings in this paper are part of a larger study entitled 'Health in hand-intensive tasks and safety (HITS)', which was funded by the Institution of Occupational Safety and Health (IOSH). Our final study sample consisted of 347 employed and self-employed practising therapists in Ireland. Of these 347 therapists, 141 were physical therapists and athletic therapists, with a response rate of 76%; 135 were chartered physiotherapists in private practice with a response rate of 54%; and 71 were chartered physiotherapists in hospitals with a response rate of 31%. Mailed questionnaires included questions about demographics and work history; WRMSD symptoms (back, neck, shoulder, elbows, wrists, fingers and thumbs); clinically diagnosed upper-limb disorders; physical-work risk factors (repetitive movements, duration of postures and exertion); psychosocial and work-organisational risk factors (quantitative work demands and tempo, emotional work demands, influence at work, predictability and social support, scheduling, and rest breaks); injury-prevention training; health and safety risk assessment; and self-care strategies. Descriptive statistical analysis was completed to determine the prevalence rates of WRMSDs in the sample population. Statistical analyses will be presented in a non-academic format.

### Results

The majority of the participants were female (67%) with a near equal gender balance in the group of physical therapists and athletic therapists (53% females to 47% males). The average age of all participants was 39 years, with a range of 23 to 72 years. The study sample included highly experienced therapists, as well as therapists at the beginning of their career. In total, 55.4% of all participants reported that they had experienced work-related musculoskeletal pain or discomfort that lasted for more than three days in the past 12 months. In support of findings from previous studies, the prevalence of back symptoms was high. Low-back symptoms (pains, aches, discomfort and numbness) accounted for the majority of back symptoms, with a 12-month prevalence of 48.8% and a seven-day prevalence of 24.4%. Nearly one in five therapists (18.4%) suffered from low-back symptoms during the past 12 months that were so severe they were incapacitated and were prevented from carrying out normal activities at work, home or during leisure time. The back was one of the most commonly affected body parts in the study population.

In relation to upper-limb symptoms, a very large proportion (82.5%) of therapists experienced symptoms (pain, aches, discomfort, numbness) in at least one upper-limb body part during the last year. More than half of all therapists (53.9%) had experienced upper-limb symptoms during the past seven days. One out of four therapists (25.7%) suffered from upper-limb symptoms during the past 12 months that were so severe they were incapacitated and were prevented from carrying out normal activities at work, home or during leisure time. The most affected body parts accounting for the 12-month and 7-day prevalence rates were shoulder, neck and thumbs. A total of 53.2% of all respondents reported that they experienced shoulder symptoms (aches, pain, discomfort) during the past 12 months, followed by neck symptoms (49.4%), thumb symptoms (46.2%), wrist symptoms (34.2%), elbow symptoms (28.2%) and finger symptoms (25.3%). Women reported significantly more neck and shoulder symptoms (56.3% and 57.6%, respectively) than their male counterparts (35.4% and 44.2%). Self-employed therapists reported a higher 12-month prevalence of upper-limb symptoms (86.4%) compared with employed therapists (76.5%). Although a sizable percentage of participants reported that they had shoulder and neck symptoms before training as a therapist (21% and 19%, respectively), the respective percentages were low for the other body parts, e.g. elbows (3.4%), wrists (3.3%), fingers (7.8%) and thumbs (5.2%), suggesting that onset of symptoms, especially affecting the arms and fingers, may be, at least partially, work-related.

### Conclusion

This study found evidence for high MSD prevalence rates for all indicators of musculoskeletal health used. The high occurrence of musculoskeletal health problems and their significant effects on daily life, including work activities, warrants further specific attention by the health and safety, academic and practitioner community. Strong working relationships between these groups are essential to allow research to translate into practice.

*Keywords: Musculoskeletal disorders, low-back pain, upper-limb disorders, prevalence rates, healthcare workers*

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## 5. Can we improve learning from incidents? And how?

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**Linda Drupsteen** – Foundation for Applied Scientific Research (TNO), Netherlands;  
**Gerard Zwetsloot** – Foundation for Applied Scientific Research (TNO), Netherlands / Nottingham University, UK

According to the International Labour Organization (ILO), “every 15 seconds, somewhere around the world, someone dies as a result of work-related injury”; that is four persons a minute, or 240 persons in an hour. Organisations make many efforts to reduce this number – i.e. to prevent accidents. However, not only is this number an indicator of why accident prevention is still a relevant topic, it is also a number of situations that provide input from which to learn. On top of these events, delays, material damage, disturbances, and near-misses also provide possible learning opportunities. All this information could be used for learning, once an organisation is able to learn.

Learning from events means that an event is analysed, lessons are identified, and the lessons are implemented as actions for improvement and evaluated for their effect. Moreover, an evaluation of the process may also allow for improvement of the learning process itself – i.e. learning to learn. The study we present here focuses on learning from incidents, whereby the use of lessons learned contributes to the prevention of (similar) future incidents and to the improvement of safety and efficiency in the organisation. The study was part of a research project on ‘safety as part of the core business’ of



organisations. Other topics in the overall research project were safety culture, safety indicators, and team resilience. The study on learning from incidents was performed between 2010 and 2013.

The 'learning from incidents model' that is used in this study consists of five phases: collecting information; investigation and analysis; planning actions; implementing actions; and evaluation. The model illustrates that in each phase of the learning process weaknesses may arise, and that it is one process in which investigation, follow-up and evaluation are all connected. The model is used to study when the learning from incidents process was hindered and what caused these hindrances to effective learning. These questions were studied by means of a survey, case studies and focus groups in seven organisations. The aim of this study was to identify causes for ineffective learning, so that the causes could be addressed and learning from incidents in organisations could be improved.

The results of the study indicated that difficulties may arise in any phase of the learning process, but most difficulties were identified in the phase of planning actions, which is the phase that bridges the gap from incident investigation to actions for improvement. The main causes for learning difficulties identified by the participants in this study were tightly related to the learning process, such as: the quality of incident reports was limited; systematic causes were not addressed in the investigation; and planned actions were not performed. Some indirect causes – or conditions – such as lack of ownership and limitations in expertise, were also mentioned. These results indicate that direct and indirect causes (or latent conditions) can be identified for the failure to effectively learn from incidents. This implies that to improve learning, such latent conditions need to be identified and addressed, with a similar approach as when studying accidents.

*Keywords: Learning, organisation, failure causes, safety management, case studies*

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## 6. Bridging the gap between research and practice: the IRSST's experience

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**Paul-Émile Boileau – IRSST, Canada**

As an organisation involved in research in the field of occupational health and safety, IRSST has always stressed the importance of disseminating knowledge to the end-users to obtain a genuine impact on workers' health and safety. Although the approach initially relied on disseminating results only after the research was completed, it became apparent that there was a need to involve workplaces right from the beginning of the research to ensure optimal adaptation and promotion of the results. A code of practice on knowledge transfer was thus adopted at IRSST, which relied on the continuous interactions between the researchers and the workplaces concerned with the project, from the development phase until its completion. This code of practice involves the constitution of follow-up committees, which include the researchers and representatives of the various stakeholders, including employer and worker associations, prevention associations, and workplaces. Through the support of knowledge-transfer advisors, these committees have been active in providing input while the research is being planned, following the progression of the research, and proposing appropriate knowledge-transfer strategies.

Since the adoption of the code of practice on knowledge transfer, more than 100 projects have been supported on an ongoing basis by follow-up committees, which have involved representatives from more than 200 organisations. Several of these projects have led to knowledge-transfer activities through which a vast range of products has been made available to make the results more accessible to the end-users. These have included the production of videos, websites, fact sheets, practice and technical guidelines, directories, analysis grids, computer-based tools, seminars, and conferences. All the



knowledge-transfer activities have involved the participation of the knowledge-transfer advisors and the researchers, with the support of the follow-up committees.

The code of practice on knowledge transfer adopted at IRSST involves four steps: anchoring of the research project with the need; conducting the research; translating the knowledge; and evaluating the impacts. Through some examples of completed knowledge-transfer activities, this paper will report on the specific involvement of the follow-up committees at each step of the knowledge-transfer code of practice, while putting particular emphasis on the transition between the research and the knowledge translation. Factors that have contributed to deciding which type of medium and contents would be best served to transfer the knowledge will be identified and discussed. Examples of knowledge-transfer activities retained will include: the production of fact sheets to show how to prevent the occurrence of musculoskeletal disorders to the upper extremities, in the automobile repair shops; the creation of a website on the prevention of violence in the workplace; the production of a video to provide insight on the prevention of health problems in emergency call centres; the organisation of a research exchange network addressing the issue of manual-handling practice to prevent musculoskeletal disorders; and the production of an interactive Web-based selection tool to support the identification of protective gloves against mechanical risks. For each of these, a brief description of the research at the origin of the knowledge-transfer activities will be given, along with a discussion on some potential metrics that could serve to measure the impact of research.

*Keywords: Research, knowledge translation, impact of research, occupational health and safety, follow-up committees*

# TECHNICAL SESSIONS TS7–TS9

## Thursday 02 October, 11.00–12.30

### Technical session 7: Using safety knowledge

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1. The fog of work: The necessity for black and white, and grey rules to ensure safe workplace behaviour

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Ruth Hartley, Andy Dainty, Alistair Cheyne, Patrick Waterson, Alistair Gibb, Roger Haslam, Jennifer Morgan, Aoife Finneran, Phil Bust – Loughborough University, UK; Sarah Pink – RMIT University Australia and Loughborough University, UK

#### Research context

In line with the notion of factional approaches to occupational safety and health (OSH), Dekker (2003, 2005) outlined two perspectives on rule development in the workplace: model 1 (procedure application through rule following) and model 2 (procedure application as substantive cognitive affectivity). Hale and Borys (2013) developed these notions further outlining the advantages and disadvantages of each.

#### Model 1: Top-down classical rational approach to formally pass on OSH information

From this perspective there is 'one best way', which can be dictated by formal procedures or rules.

These are devised in advance by 'experts' and imposed and implemented by management. This is a logical and rational approach – both the rules and the consequences of breaking them are explicit. Rules of this type are said to be good for novices and useful when 'golden rules' (key rules or checklists that aid fast working or must not be broken because of the extreme consequences) are necessary. However, this approach cannot deal with anomalies well, can result in a blame culture, and disempowers workers.

#### Model 2: Bottom-up constructionist approach to socially constructed practice

This approach indicates that a range of behaviours is acceptable within permissible boundaries. In this context, workers are experts and apply their experience and knowledge to develop rules. Rulemaking is ongoing and dynamic, evolving in an ever-changing working environment. This approach is said to deal better with the ambiguous realities of work. However, there are limitations to this approach: it lacks transparency and can therefore be difficult to audit and be problematic for novices. The role of the organisation is diminished and the active management of rules is undervalued.

Dekker (2003) indicates that where there is a focus on model 1, it results in a 'double bind'. A 'double bind' occurs when there is a gap between procedures and practice, i.e. workers can fail to adapt to a problem when adaptation is necessary or workers attempt an adaptation that results in a problem. Rather than seeking to increase compliance through the application of pressure, organisations should try and understand the gap between procedures and practice, and address competencies that will help workers adapt to new situations. Moreover, Hale and Borys (2013) suggest that a combination of the classical rational and constructivist approaches will enable organisations to manage safety more effectively. They propose a 'framework of rule management', and call for more research exploring how rules are used in practice, and ethnographic research in this field.

The research presented here is part of a project funded by the Institution of Occupational Safety and Health (IOSH). It involves an investigation of different types and sources of knowledge and information in three sectors in an attempt to uncover how workers use procedures, developed from models 1 and 2, and bridge the gap between the two extremes to develop safe practice.

## **The project**

### **Background**

The research outlined here is the result of a multi-disciplinary project, which brought together engineers, ergonomists, ethnographers, sociologists and psychologists, entitled 'Management of OSH in networked systems of production or service delivery: comparisons between healthcare, construction and logistics'. The project aims to identify what types of OSH knowledge and evidence are in circulation and how they interact with each other in networked organisation. More specifically, it aims to investigate how workers interpret the multifaceted information to which they are exposed, and how this interpretation, in dynamic work contexts, influences their behaviour. The data obtained illuminate how top-down rules (explicit information) and socially constructed knowledge manifest and combine in different types of organisations.

### **Method**

Data were collected from three industries: healthcare, construction and logistics. A combination of qualitative methods (interviews, focus groups) and ethnography was used. Thirty face-to-face interactions were completed for each industry. Interview and focus-group inventories addressed: sources of information; the creation of information and rules; the translation and dispersal of information within organisations; and, ultimately, the enactment of safety within complex working environments. An ethnographer spent 25 days in each organisation and used a combination of methods: observation, visual, interviews, and participant observation, in order to better understand the enactment of OSH in practice.

### **Results**

In practice, both types of rule formation occur concurrently, with organisations producing both top-down rules and facilitating constructivist approaches. The working environment influenced the type of approach taken. In controlled environments top-down approaches are more likely; however, in dynamic environments expert workers are given the means to develop their own practices. Workers operate in a hinterland, in which they use a combination of formal rules and informal learning and experience to determine their behaviour. When questioned and observed it becomes apparent that workers are often using a combination of top-down, socially constructed and experiential expert knowledge to inform their performance of a given task. For example, delivery drivers use a combination of formal manual-handling training, experience, and 'on-the-job' learning from colleagues to manoeuvre goods into customers' homes. Behaviours varied depending on the circumstances, with workers evaluating their course of action, having taken account of multiple variables. For example, workers may or may not ask for help lifting a heavy object depending on the proximity and workload of their colleagues – if their colleague is busy or some distance away, they will not ask for help; if they are close, they will ask for help. Rules are adapted, but this does not necessarily compromise safety, as workers are able to apply their knowledge to adjust to situations. When rules were broken, with resultant negative consequences, evidence of 'the gap' was sometimes found.

### **Conclusions and implications**

In practice, classical rational and constructionist rule development are conjoined and symbiotic. In dynamic working environments their manifestation is complex, with the influence of either approach waxing and waning depending on circumstances. Our data reveal good practice within organisations that manage the transfer of OSH knowledge well, i.e. they recognise the value of both approaches and adapt their strategies depending on the job role and situation.

*Keywords: Safety rules, practices, safety management, multi-disciplinary*

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## 2. Organisational learning for increased value and improved occupational health and safety in the fire brigade

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Johan M Sanne – IVL Swedish Environmental Research Institute, Sweden

### Background

City councils around the world expect increased value from the fire brigades in terms of fire prevention, emergency medicine, fighting crime, and environmental protection. Firefighters are therefore exposed to new and varying occupational-health hazards, such as occupational accidents, exposure to dangerous substances, public violence and threats, as well as post-traumatic stress. Previous research shows that learning from rescue efforts needs to be improved in several respects. There is a need to know more about: the rationale that shapes firefighters' actions; how they do risk assessment; how they evaluate accident scene management; and how learning from events might be used to improve future actions.

### Purpose

The paper addresses how the fire brigades can simultaneously bring increased value and successfully manage occupational hazards, which the occupational health and safety management literature suggests is more efficient than to pursue these activities separately.

### Methods

The paper analyses how the fire brigade managed 36 accidents of four different kinds, chosen from three different Swedish fire brigades, and how learning from these might be used for future improvement, based on documents and interviews with firefighters, safety representatives, managers, and union representatives.

### Findings

Learning is shaped by various 'risk objects' that define what actors see as causes of accidents and how these should be managed, while 'risk objects' are shaped by firefighters' occupational community. There is a strong sense among firefighters of accident scene management as the real work, especially smoke firefighting, as opposed to preventive action and medical care. Learning is also shaped by organisational conditions, such as training, missions, time limits, and tools, including checklists, which in turn also influences 'risk objects'. When training, tools and time are inadequate for collecting relevant data about rationale, risk assessment, and evaluation of action taken, learning is impeded. Therefore, there is often a lack of information in the documentation regarding goals, risk assessment, and evaluations for specific actions taken, which makes it difficult to evaluate the effects of those actions.

Organisational learning takes place when individuals' knowledge is codified into new technology, new routines and directives. There is an understanding that learning from the evaluation of accident scene management is impeded by the way fire brigades organise, such as a lack of trust between firefighters and fire engineers, current team organisation, and working schedules.

### Implications

The paper increases knowledge on how organisational development can integrate increased value, as well as improved occupational health and safety, and what that integration requires. Fire brigades need to scrutinise and change organisational conditions for learning from accident scene management, e.g. include firefighters in: learning from accident management; asking them about what shaped their actions, their risk assessment and what informed it; and when designing new tools for guiding future actions. Fire brigades also need to design means for firefighters and fire engineers to overcome current mistrust and to discuss new ways to serve citizens – ways that conform to policy expectations and can improve occupational health and safety for firefighters.

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### 3. The use of a professional code of conduct as a learning resource

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**Alison Caswell, Tim Briggs – Leeds Metropolitan University, UK**

In areas such as nursing and the allied health professions, where degree awards are linked to professional registration, and authorisation to practice is subject to strict controls, there is an associated requirement for the education provider to have professional suitability regulations in place to ensure that students who demonstrate behaviours that would render them unsuitable to practise are unable to achieve the award. Such regulations are typically based on the professional body's code of conduct, and there is an obligation on the education provider to ensure that students are aware of both the local regulations and the regulations governing their future profession.

There is evidence that professional suitability regulations are now being applied to a wider range of courses leading to professionally accredited qualifications – for professions, including in the area of health and safety, in which there is currently no regulation of whom may practice – with a consequent requirement that students are taught about these.

IOSH, as a professional body, established a professional code of conduct during the 1990s and the code has been updated and refined to reflect updated practice. As the profession matures, it also reflects the stature of the profession. The current IOSH professional code of conduct was revised and became effective from March 2013. In 2011, the IOSH core curriculum was reviewed and, as such, now includes the mandatory requirement for the professional code of conduct to be addressed within the delivery of the teaching materials.

There are clearly various ways in which the requirement to 'teach' the professional code of conduct and any associated local professional suitability regulations could be met, but this presentation will seek to demonstrate that coverage of this area can be used to foster the personal and professional development of students, through an emphasis on the key qualities espoused by the professional code of conduct, i.e. competence, respect, integrity and service, within a framework that encourages a reflective practitioner approach to continuing professional development.

Evidence in support of this view will be provided through consideration of current practice on the BSc (Hons) Safety, Health and Environmental Management course at Leeds Metropolitan University, a review of feedback from students on this course, and a report of a small pilot study involving a questionnaire that has been completed by staff delivering IOSH-accredited courses at other UK higher education institutions.

The presentation will conclude with suggestions as to how further assessment might be made of the effectiveness of this approach in the fostering of a culture of continuous development within students on health and safety degree courses, and with recommendations for educational practice.

*This study has received ethical approval from Leeds Metropolitan University.*

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## 4. Ethical challenges of the occupational safety technician

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**Vanessa Coutinho, Miguel Corticeiro Neves – ULHT Lisbon, Portugal**

Professional ethics is an emerging phenomenon, arising from the constant changes in society, at work, and from the consequent challenges imposed on occupational safety technicians. The extent of professional ethics also reflects a risk-management strategy, since the ethical codes provide aid and orientation regarding the equity and fairness of professional conduct, alongside the technical conduct demanded for the exercise of the profession. In the past decades, occupational safety has grown and developed in several key sectors of activity in Portugal, and there is an estimate of about 40,000 technicians in practice. The lack of a Portuguese ethical code, common to all the technicians, and abiding them all to ethical principles and standards essential to their conduct, is a major flaw in our occupational safety community. As far as the legislation that regulates the professional activity of the Portuguese occupational safety technicians is concerned, there are several principles that combine both technical and ethical standards, but there isn't a true guideline that reflects the most relevant issues of the professional practice, especially those who deal with the most delicate areas of intervention, such as ethical dilemmas.

The purpose of this investigation is to trace an overview of the knowledge of ethical principles applied to the professional practice of the Portuguese technicians and gather relevant information from major personalities of the national occupational safety community, in order to establish the basic principles that should figure in an ethical code of conduct that truly reflects the reality of practice. The bottom line addresses to collect information that allows the establishment and development of principles that merge both the technical needs and idiosyncrasies of practice and the cornerstones of ethics, such as respect, competence, responsibility and integrity. The method applied both addressed the technicians, at a national level, by applying a questionnaire, and several prominent individuals, by conducting interviews to retrieve relevant data regarding the evolution of the professional practice in Portugal since 1991. The questionnaire had 20 direct questions regarding knowledge of ethical principles applied to professional conduct, and three open questions that aim to highlight the professionals' concerns and needs in this field. Also, a bibliographical review allowed an international framework of occupational safety ethics, stressing the most important aspects of the ethical conduct required.

The results indicate several aspects of professional conduct that need to be addressed in an ethical guideline. The Portuguese professionals seem to be substantially driven by technical principles, and lack more profound reflection oriented by ethical standards. On the other hand, the results point to a lack of insight of their own professional conduct regarding the fine line that distinguishes technical conduct from ethical behaviour. The development of a Portuguese ethical code of conduct for occupational-safety technicians, based on the results gathered, could establish the essential requirements for the technicians to support their decisions, in particular, when facing ethical dilemmas. It could also reflect the idiosyncrasies of practice in the country, and address the most sensitive aspects reported by the professionals. Such a code should stand as a high-priority issue of both the professional and scientific community, promoting the quality of practice and elevating the profession to its highest level.

*Keywords: Professional ethics, guidelines, principles, dilemmas*

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## 5. Participating in voluntary safety initiatives: how you look at it and what you get from it – linking perceived management commitment to safety, safety knowledge and motivation through safety citizenship role definitions and discretionary safety activities

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**Julie Laurent, Isabelle Hansez** – University of Liège, Belgium; **Nik Chmiel** – University of Chichester, UK

### Background

Chmiel and Hansez (2013) proposed a predictive relationship between the perspective that employees take on voluntary safety activities and their on-the-job violation behaviour. If employees considered voluntary activities to be more a part of their job they were less likely to violate safety rules and procedures. Chmiel and Hansez argued this was because adopting such a perspective leads employees to take part in more voluntary safety activities, such as volunteering for the safety committee and trying to improve safety by suggesting new procedures, and these activities, in turn, would serve to raise awareness of the importance of adhering to safety rules and regulations, and provide knowledge of how to do so, leading to safer working. This view is consistent with the study by Hofmann, Morgeson and Gerras (2003) reporting that employees' definition of discretionary safety behaviours as part of their job – safety citizenship role definitions (SCRDs) – is linked positively to corresponding safety citizenship behaviours.

Chmiel and Hansez (2013) also reported that employees' perceptions of management's commitment to safety predicted their perspective on discretionary safety activities or SCRDs: the more employees consider their management to be committed to safety the more they consider voluntary safety activities as part of their job. Since Neal, Griffin and Hart (2000) have argued that perceptions of managements' attitude and approach to safety predict compliance with safety rules and procedures through employees' safety knowledge and motivation, a position endorsed recently by Christian et al (2009), we test the hypothesis that the predictive relationship between perceived management commitment to safety, and safety knowledge and motivation, is mediated by employees' perspectives on discretionary safety activities (their SCRDs), and their participation in said safety activities.

### Aim

On the basis of the proposal made by Chmiel and Hansez (2013), we test their hypothesis: if employees perceive their management values safety, they will respond by considering safety-related discretionary behaviours as a bigger part of their job, which will lead to more safety motivation and safety knowledge through participation in safety-related discretionary activities.

### Method

#### Sample

Participants were 309 employees in a Belgian chemical industry. Concerning hierarchical responsibilities: 46.56% (n=142) of the sample were workers without subordinates; 26.23% (n=80) had between one and five subordinates; 8.52% (n=26) between six and 10 subordinates; and 16.39% (n=50) had more than 11 subordinates (seven unspecified). Concerning the age of participants: 3.28% (n=10) were less than 25 years old; (n=74) between 25 and 35; (n=104) between 36 and 45; (n=78) between 46 and 55; and (n=32) were more than 55 years old (seven unspecified).

## Measures

Perceived management commitment to safety was measured with eight items used by Hansez and Chmiel (2010). Safety citizenship role definition was measured with four items from Hofmann, Morgeson and Gerrass (2003) and used by Chmiel and Hansez (2013). Safety motivation, safety knowledge and safety participation were measured with items used by Griffin and Neal (2000).

## Data analysis

Structural equation modelling analyses (SEM) were performed using LISREL 8.80 (Jöreskog and Sörbom, 2006). First, the measurement model was assessed with a series of confirmatory analyses to test the independence of the constructs examined in our study. Second, we assessed the hypothesised structural relationships among latent variables we compared with alternative models. Bootstrap analyses were performed using SPSS to examine indirect links between variables.

## Results

Results show two significant double mediations in our model, in which low SCRD and participation are mediators. Indeed, PMCS significantly predicts low SCRD, which leads to both safety knowledge and safety motivation through safety participation.

Thus, perceiving management as committed to safety (PMCS) significantly leads workers to define discretionary safety behaviours as part of the job (low SCRD,  $Y = -0.26$ ,  $p < 0.001$ ), which is linked to corresponding discretionary behaviours ( $\beta = -0.34$ ,  $p < 0.001$ ). Participating in such discretionary activities, in turn, leads to: 1) a greater knowledge of safety rules and procedures ( $\beta = 0.57$ ,  $p < 0.001$ ); and 2) a greater motivation to adhere to such issues ( $\beta = 0.40$ ,  $p < 0.001$ ).

## Conclusion: implications

These results support the importance of considering PMCS and SCRD when we focus on safety performance issues. Taking part in discretionary safety behaviours facilitates workers' knowledge and motivation to respect safety rules and procedures.

Future research should add safety violation behaviours as outcomes of this model and, in this way, incorporate contextual and task-related performance in the same framework.

A practical implication is that organisations should consider the critical role of management, as well as the importance and consequences of their commitment to safety concerns. Indeed, HR practice and social processes should be oriented towards workers' stimulation of defining security as an integral part of their role through managers' awareness.

*Keywords: Perceived management commitment to safety, safety citizenship role definition, safety performance, motivation and knowledge*



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## 6. Balancing rules with improvisation

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**Frode Heldal** – Trondheim Business School; **Stian Antonsen** – NTNU Social Research, Norway

A lean production team is normally characterised by having at least some work processes standardised. This can be to a greater or smaller extent, depending on the context and task. The amount of standardisation is, however, always difficult, and needs a dynamic approach. This dynamic is especially pertinent when it comes to safety. This article focuses on safety in industrial plants, with a special emphasis on group dynamics at the shop floor related to safety. Safety is, by its own, a unique area to address, because of its heavy focus on predetermined rules and regulations. This static and rigid context becomes even more pressing when the system is lean. Still, accident analyses have shown a need for teams to improvise and be flexible when a disaster builds up. This entails at least some kind of autonomy and dynamicity on behalf of the teams. How do we enable teams to become both static/rule-obeying and dynamic/creative at the same time? In other words, how do we balance rules with improvisation?

### Theoretical considerations

**Safety and team performance:** Entrainment entails the process whereby one or more activities are set to oscillate in rhythm with others (*idem*). Such guiding or management of team processes is supposed to improve team development for a number of reasons (McCallin, 2003). It may, for instance, improve team identification, which is said to correlate with team performance (Gundlach *et al*, 2006). It also contributes to developing a shared mental model. This improves the coordination between collaborating actors and, subsequently, leads to improved performance (Standifer and Bluedorn, 2006).

Further, it is important for team development that social role structures dissolve (Sjøvold, 2006). Within a team with well developed and mature relationships, the role structure is often difficult to grasp, as it changes continuously (Sjøvold, 2007). But in a team with less developed social relationships, the role structures are rigid and not contested (*ibid*). In a pre-planned context, teams will often suffer from having a static role structure (by its very nature). This will enable them to perform swiftly and efficiently but, sadly, they lack the dynamic needed when something unexpected unravels (Weick *et al*, 1999).

**Safety and lean organisations:** The definition of what is to be seen as unnecessary waste is not uncontroversial (Womack *et al*, 1990). What a disciple of lean manufacturing is likely to label as waste may be viewed as critical resources for safety. For instance, the notion of 'slack', referring to redundancy of personnel and overlaps in competence, is likely to be a red flag of inefficiency from a lean point of view, but has been shown to be critical for the avoidance of major accidents in high-risk industries (e.g. LaPorte and Consolini, 1991; Schulman, 1993). This points to an inherent tension between efficiency and safety, which will need to be resolved or balanced by production teams. It involves a form of paradox related to team performance, in that a team can be a success and an accident waiting to happen at the same time, depending on which standard for team performance is used.

### Material and methods

Twenty-two in-depth interviews and 10 hours of participating observational studies were conducted. In addition, operators completed a survey based on the contention between safety and efficiency (respondents exceeding 50%). Our main question was: How do we make shop-floor teams develop a dynamic and proactive attitude when both lean management and safety regulations push them in the other direction?

## Results – a model for organisational improvisation

The results revealed that shop-floor teams were eminent in performing technical tasks, or tasks that could be planned in advance. However, this implied, at the same time, a lack of abilities such as communication, team leadership, learning, and cooperation – elements that, in essence, could not be pre-planned. We call these non-technical skills – an expression borrowed from surgeon team-training. Non-technical skills are generic skills that underpin and enhance technical tasks, improving safety by helping people to anticipate, identify and mitigate against errors. In our approach to making teams more proactive, we suggest a model for organisational improvisation that builds on Salas' five-factor model (Morey *et al*, 2002), HRO and resilience thinking (e.g. Weick, 1987; Weick *et al*, 1999; Weick, 2001), Sjøvold's team relationship model (Sjøvold, 2006) and general theories of organisational improvisation (e.g. Barrett, 2012). The result is a tool that teams may use themselves to train and develop proactivity under rigid conditions.

*Keywords: HRO, organisational improvisation, team leadership, operational safety*

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# Technical Session 8: Promoting safe behaviour

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## 1. Encouraging postural breaks – findings from a two-year behaviour-change study

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**Claire Williams** – University of Derby / Human Applications; **Elaine Denning, Andrew Baird, David Sheffield** – University of Derby, UK

This project investigated the impact of behaviour-change interventions on postural break-taking behaviour, within a constrained office-type environment (e.g. call centres/control rooms). Musculoskeletal disorders (MSDs) are still the most common occupational ill-health condition in the UK. Though MSD aetiology is often complex and multifactorial, adequate postural rest breaks have been shown to impact on reported symptoms and related issues, such as fatigue and discomfort.

The need for regular postural breaks for DSE staff has been part of the guidance to the DSE regulations since their inception, and was reiterated in a 2007 HSE study. These authors further established high prevalence rates of MSDs and other symptoms in DSE workers (particularly those who reported working longer without a break), and proposed that further work should be undertaken to investigate the impact of improved break-taking on these symptoms.

The theory of planned behaviour (TPB) is a well-established and prominent model of health-related behaviour. It outlines a number of factors thought to impact on the intention to behave in a certain way. The model does, however, recognise a clear gap between behavioural intention and actual behaviour.

Initiatives aimed at changing behaviour must therefore aim both to influence behavioural intentions and to 'bridge' the intention-behaviour gap. One such gap-bridging method is the writing of implementation intentions (if-then plans). These have been used effectively to help turn intention into behaviour for other issues in office environments, and this study looked to identify whether such interventions might influence break-taking behaviour.

In addition to implementation intentions, a number of studies has looked at whether external prompts or reminders can support the translation of intention into behaviour. To that end, this study also used a buzzing prompt from a BACK-TRACK™ device to remind participants to take a postural break. We looked at whether these plans and prompts increased the number of short (30-second) postural breaks taken by 'desk-bound' office staff.

Our results demonstrate that:

- At an average of more than three, 30-second or longer postural changes an hour, the level of break-taking exhibited by participants in this study is surprisingly high. Even the lowest recorded figures of 0.82 breaks/hr would not cause major concern in the context of typical DSE guidelines.
- Exposure to static posture is a risk factor for the development of MSDs and lack of breaks form part of the picture. This study suggests that these office workers interrupted that exposure frequently, and that prolonged static postures in the typical office are perhaps less of an issue for MSDs than previously thought.
- Writing if-then statements doubles the odds of making a meaningful increase in postural break changes over a day, compared with not writing them. For an effectively 'free' intervention, this is an important finding.
- This indicates it is worth incorporating the writing of these plans into initiatives to increase postural

- breaks, and considering their use in other health and safety initiatives aimed at changing behaviours.
- BACK-TRACK™ devices, currently used in a manual-handling context, show some promise for office break-taking behaviour change.
- Participants reported that simply wearing the BACK-TRACK™ encouraged them to get up more, that an external prompt such as that provided by the BACK -TRACK™ would be useful, and that feedback about performance (which is possible via the reporting database at BACK-TRACK™ Ltd) would also aid change.
- Six areas should be considered when undertaking behaviour-change interventions; these will be discussed as part of the presentation.

This study has given us a better understanding of break-taking behaviour at work. It has indicated that, in fact, office workers, even in ‘desk-bound’ settings, may get up more than would typically be expected. This knowledge should encourage practitioners to focus attention on the other risk factors for MSDs, such as overall workload, poor posture, and psychosocial factors.

*Keywords: Behaviour change, MSDs, ergonomics*

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## 2. The development of a Dutch guideline to promote safe behaviour in industry

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**Frank Guldenmund** – Delft University of Technology, Netherlands; **Andrew Hale** – Health and Safety Technology and Management Ltd (HASTAM), UK

Guidelines are a physician’s and general practitioner’s goldmine. Guidelines are very common in the medical profession and they provide physicians with evidence-based information on how to proceed in case of many medical treatments. When a physician wants to deviate from guidelines s/he must have good reasons for not following them. In contrast, most safety professionals do not work according to such guidelines – at least, not in the Netherlands. In the most favourable case, they work according to ‘best practices’; in the worst, they ignore any information available to support their practices.

To bring about some change in this state of affairs, the most important institutions concerned with occupational safety in the Netherlands – the Dutch Ministry of Social Affairs and Employment, the unions, the employers, and the various associations concerned with health and safety of workers – got together to brainstorm on measures that could support safety practitioners in daily practice. One of the measures this group came up with was the development of several guidelines that would follow the medical example of bringing together evidence-based safety measures and practices. For the first round of guidelines to be developed, a shortlist was assembled. Topics on this list were: lifting, work pressure, aggression at work, and welding smoke. This paper discusses the development of the guideline at the top of this list: the promotion of safe behaviour in industrial settings.

At the start of the present project, a project team was assembled, consisting of the author of the guideline, a supervisor and co-author, and a secretary. The project team was supported by a group of experts that came together several times during the development of the guideline. Beforehand, it was already decided that the guideline should focus on ‘production industries’. Production industries were defined as industries engaged in fabrication (non-food) and construction. Exploitation (mines, wells) and transport of produce were excluded from the guideline’s scope.

Guidelines provide evidence-based practices and measures supporting the practitioner to carry out his job in a responsible way. These measures or practices are ideally taken from scientific studies, although

professional publications might also be included, which are selected through extensive literature searches in various databases. To be able to capture a broad array of intervention studies, it was decided to use studies that used lost-time accidents as a primary outcome measure. Lost-time accidents were defined as personal accidents resulting in time away from work for more than 24 hours. Given these boundary conditions (production industries and accidents), a literature search was carried out using the most important databases.

In the Netherlands, the so-called EBRO system is used to develop guidelines for medical purposes (EBRO stands for 'evidence-based guideline development' in Dutch). Following the EBRO system, studies are classified according to the weight of evidence or proof, which is determined by the design of the study through which the effect of the measure or practice is established. Studies can be ordered hierarchically, according to their weight of proof.

An initial literature search provided 22,000 hits, but these were reduced to 53 publications to be discussed in the final guideline. Successful behavioural interventions were ordered following the EBRO system and types of interventions were classified according to the development model of culture, derived from Bergman and Luckmann's seminal work on social constructivism. This relationship between behavioural interventions and organisational culture was sought explicitly to embed interventions in an organisational culture. The development of interventions followed a rather straightforward path of: deciding on a behavioural intervention; choice of intervention; implementation of intervention and measuring performance indicator(s); and securing and evaluating the intervention through the performance indicator(s).

As of now, the first six guidelines are publicly available, but their legitimacy is still under discussion – that is, should the guidelines be enforced to the extent that only a well-motivated deviation is allowed, or do they function just as a handy resource for when a professional is looking for some guidance.

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### 3. The role of safety climate on workers' risk-acceptance level in furniture companies: a multi-level approach

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**Matilde Rodrigues** – School of Allied Health Technology of Institute Polytechnic of Porto/University of Minho; **Pedro Arezes, Celina Leão** – University of Minho, Portugal

Previous studies argue that cultural beliefs rooted in a group define the level of risk considered acceptable for that group, having a direct or indirect influence on their safety decisions and risk beliefs. With respect to occupational safety, the concept that emerges is the safety culture.

Safety culture is the reflex of the organisation in relation to safety, i.e. how the organisation is and the factors that determine its commitment to safety and health (norms, values, attitudes and perceptions, competences, assumptions, behaviours, beliefs, and expectations). Therefore, safety culture is a difficult concept to measure. Because of this, most previous studies have focused on the concept of safety climate, which is seen as a product/sub-component or an indicator of safety culture, and can be analysed more easily.

Despite the importance of previous studies on safety culture or safety climate – particularly the studies that analyse its relationship with risk perception, management systems, safety behaviours, and accident rates – studies about its influence on the level of risk acceptance are scarce. However, this is an important analysis because it allows a better understanding of how workers form their opinion about

a given risk and why they adopt a certain attitude towards risk. In this context, the current study aims to analyse the relationship between safety-climate level and the workers' risk-acceptance level, and it was carried out in the Portuguese furniture sector. Furthermore, this study also analyses the relationship between safety climate and the companies' safety performance.

In total, 14 Portuguese furniture companies were studied. The analysed companies varied in size from micro to medium-sized companies. Thirty-three work groups, composed of 403 workers, were considered for the study. The assessment of the safety climate, considering a multi-level structure, was performed by the use of the Safety Climate in Wood Industries (SCWI) tool. The SCWI was previously validated and includes two main parts: the first part comprised workers' demographic questions; and the second part included 34 items for measuring safety climate, analysing three different levels (organisational, group and individual levels).

The companies' safety performance was analysed through the application of a checklist. Judgements about risk acceptance were measured through a questionnaire, together with four other variables – namely trust, risk perception, benefit perception, and emotions. The analysed variables were measured through five-point Likert type scales. Questions about risk acceptance, risk perceptions and emotions were based on scenarios, six of which were related to cuts, five to musculoskeletal disorders (MSDs), and one to a fatality. To analyse benefits perceptions, two groups of questions were included, i.e. benefits for the employer, and benefits for the employees. Trust was measured at three different levels, i.e. management decisions on risk control; the action of occupational health and safety (OHS) professionals on risk control; and supervisors' action to enforce the rules and safety procedures.

The obtained results showed a strong linear positive relationship between safety climate scores and the safety performance ( $r=0.836$ ,  $p<0.001$ ), meaning that the companies with higher levels of safety climate also generally present better safety conditions. Furthermore, differences on safety climate among work groups were observed, indicating the presence of multiple sub-climates. The groups related to storage and assembly departments present the highest safety climate scores for the different hierarchical levels analysed, as opposed to groups related to the cutting sector, which have the lowest safety climate scores. In fact, almost all the analysed companies in the cutting sector present a critical problem, which is related to machines without safety protection, making this sector more problematic in regard to safety.

In relation to the analysis of the influence of safety climate on the level of risk acceptance, the results showed that the individual scale of safety climate was directly and negatively correlated with most risk-acceptance scenarios ( $r<-0.280$ ,  $p<0.05$ ). Risk perception was found positively correlated with this scale for most scenarios ( $r<0.318$ ,  $p<0.05$ ). In relation to emotions, only five cut scenarios were positively correlated with the individual scale ( $r<0.179$ ,  $p<0.05$ ). The results showed that the organisational and group levels also explain variations in the level of risk acceptance indirectly, owing to the influence on trust ( $r<0.309$ ,  $p<0.05$ ). In relation to benefits, only one scenario was found to have a negative correlation with safety climate ( $r=-0.126$ ,  $p<0.05$ ).

The results of this study show that the level of risk acceptance may differ across different work contexts, particularly between work groups. In groups with higher levels of safety climate, the safety conditions are better and workers present lower levels of risk acceptance, the trust of supervisors, co-workers and managers are higher, and the risk perceptions are higher. The fear reported is also higher, but only in relation to cut scenarios. Additionally, a higher risk-acceptance level is expected from groups with lower safety climate levels. This can lead to an increase of unsafe behaviours and to the deterioration of workplaces' safety conditions.

*Keywords: Furniture companies, risk acceptance, safety climate, safety conditions*

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#### 4. The mismatch between research and practice in occupational health and safety and the hegemony of behavioural approaches in accident analysis

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**Angela Paula Simonelli** – University of Paraná; **José Marçal Jackson Filho** – Jorge Duprat Figueiredo Foundation; **Rodolfo AG Vilela** – University of São Paulo; **Ildeberto Muniz de Almeida** – Universidade Estadual Paulista ‘Julio de Mesquita Filho’, Brazil

Brazil still has alarming rates of occupational accidents. In 2010, there were 701,496 accidents, with a mortality rate of 39 deaths per 10,000 workers. This demonstrates the fragility of the national prevention system, the difficulties faced by public institutions, and their ineffective action in the fields of labour regulations, social security and health, as well as the inefficiency of prevention programmes adopted by private companies. Recent research in Brazil has indicated some major factors leading to this inefficiency in private enterprise: practice is based on outdated models of prevention that don't incorporate the latest knowledge of the analysis and prevention of accidents. There is therefore a mismatch between what is practised by companies and the models produced by academic research. The purpose of this article is to describe the contrasting models that underpin practice in companies and in academic models, and discuss the factors that explain the permanence of outdated approaches to prevention in companies. For this purpose, a documentary analysis was undertaken on the basis of current legislation, technical standards, and manuals used in businesses, in the light of recent Brazilian academic production.

**Results:** Prevention in companies is based on Heinrich's model of behaviour safety, supported by the paradigm of human error, which justifies the practice of surveillance, control and punishment of inappropriate or unsafe individual behaviour. In general, the occurrence of accidents is considered to be due to improper or deviant behaviour and, thus, prevention is achieved by the control of norms and standards imposed by management, in line with Taylor's perspective. In opposition to this reductionist view of work and prevention, Brazilian research is based on the perspectives of organisational analysis of accidents in which factors associated with the decision process, production systems, and work organisation must be taken into consideration in the analytical process. In the Brazilian behavioural approach, it is possible that distal causes may be concealed, leaving the organisational factors (design decisions, choices of technologies, work organisation, effective downsizing, etc.) untouched. By individualising the phenomena, blaming the victims, and ignoring the fundamental causes, behavioural safety leaves the mistakes and failures of operators unexplained. So, the behavioural explanation, rather than being a theory, is, in fact, an ideology, one of whose major roles is that of concealing vested interests and of giving socially constructed events the appearance of normality.

In Brazil, one reason for the strength of the behavioural approach relates to specific health and safety regulations, because it is stated that prevention services are hired by employers. This leaves little autonomy for safety personnel to influence production systems in enterprises, as they cannot influence decisions and designs related to the production process. When an accident occurs, companies try to transfer responsibility to the workers involved to avoid liability. Thus, the present framework serves more as a mechanism to meet the legal interests of companies and public or private organisations, which helps to explain why the behavioural approach has been perpetuated for many decades. The existence of a technical standard NBR 14.280/2001, designed exclusively by corporative specialists, illustrates the scenario and shows the social legitimacy of this approach. This standard, which aims to regulate the 'Register of occupational accidents – procedures and classification', establishes a model of categorisation and determination of accident causation under three headings: personal insecurity factor; unsafe act;



and environmental condition insecurity. There are, furthermore, leading consulting firms selling safety management programmes to the largest economic groups based on these approaches.

**Discussion:** Some investigations into human error as the single cause of accidents have shown that the consequences of actions are seen almost immediately at the sharp end. On the other hand, in a safety culture that focuses on mistakes and sanctions, attributing the blame to someone maintains the power or authority gradient, which makes management prone to follow the hierarchy to its lowest level, where the sharp end is conventionally found. Despite criticism based on technical and scientific evidence, the behavioural approach still remains hegemonic in Brazil, in the professional safety community, in some public institutions, and even among workers and unionists. How is the maintenance of the behaviour approach in companies' programmes and practice to be explained? One can say that the behaviour approach is applied as a mechanism for the allocation of blame, which imposes on the workers – the victims of accidents – the responsibility for their own misfortune and, thus, ignores the role of professionals, companies and institutions themselves. Finally, it must be borne in mind that training of safety professionals is undertaken by private institutions that are not linked to research institutions.

In conclusion, there seems to be no room for more complex models of accident analysis and prevention produced by research within safety companies' programmes, since corporate interests do not regard prevention as a major goal of their business and the legal framework does not seek best practices. Thus, the challenge to improve prevention in Brazil involves such multifaceted aspects as the strengthening of the critique of the ideology of human error, the diffusion and enforcement of the organisational approach within education centres and companies, and the reformulation of the regulatory framework in such a way as to increase social and public control of the process of the elaboration of standards and regulations.

*Keywords: Safety culture, human error, research and practice, behavioural safety*

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## 5. Work engagement and perceived management commitment to safety: do they predict safety violations through the perspectives employees take on voluntary safety activities?

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**Nik Chmiel** – University of Chichester, UK; **Isabelle Hansez** – University of Liège, Belgium

### Background

Previous research has shown that both non safety-specific and safety-specific processes, involving work engagement on the one hand, and perceived management commitment to safety on the other, predict safety violations (Hansez and Chmiel, 2010). The former process is considered central to job performance in general (Rich, Lepine and Crawford, 2010), and the latter, key to safety performance (Barling, Loughlin and Kelloway, 2002; Hansez and Chmiel, 2010; Neal, Griffin, and Hart, 2000).

Bakker and Leiter (2010) characterise engaged employees as actively trying to change the design of their jobs, including negotiating job content and assigning meaning to tasks. Work engagement thus implies seeking to expand or re-define one's job role. We argue that greater engagement with one's job in a safety-critical context leads to employees broadening the way they view their jobs, including defining their roles with respect to safety to include discretionary behaviours as more 'in-role' – what Hofmann,

Morgeson and Gerras (2003) termed safety citizenship role definitions. We also report that employees' safety citizenship role definitions are linked positively to corresponding safety citizenship behaviours. We reason that relevant activities such as volunteering for safety committees, promoting safety initiatives, and making suggestions to improve safety, even though discretionary, will produce a greater awareness of risk and the consequences of not acting safely, so reducing the likelihood of violations. In addition, higher engagement with work also implies the willingness to invest more effort in job tasks, including acting more safely. Since the latter processes don't involve safety citizenship role definitions we expect a direct relationship between work engagement and violations because of them. Thus, we expect safety citizenship role definitions to partially mediate the relationship between work engagement and safety violations.

Concerning safety-specific processes, Didla, Mearns and Flin (2009) interviewed oil and gas employees, who gave as one of their important reasons for engaging in safety citizenship behaviours, that which was expected of them based on their perception of the organisation's safety culture. Thus we expect, by extension, safety citizenship role definitions to partially mediate the relationship between perceived management commitment to safety and safety violations, and so test, for the first time, whether there is a predictive relationship between perceived management commitment to safety and safety citizenship role definitions.

Lastly, Hansez and Chmiel (2010) reported that job resources predicted safety violations through both work engagement and perceived management commitment to safety, and Turner, Chmiel and Walls (2005) found a key job resource, namely job control, predicted safety citizenship role definitions. Thus, we hypothesise that work engagement and perceived management commitment to safety will mediate the relationship between job control and safety citizenship role definitions.

## **Aim**

The aim was to investigate whether safety citizenship role definitions are important to safety violations and the latter's relationships to job control, work engagement, and perceived management commitment to safety, by simultaneously exploring hypothesised predictive pathways using structural modelling and bootstrap techniques. We expected safety citizenship role definitions to partially mediate the relationship between work engagement and safety violations, and the relationship between perceived management commitment to safety and safety violations. And, finally, we expected the relationship between job control and safety citizenship role definitions to be mediated by work engagement and perceived management commitment to safety.

## **Study method**

The study surveyed a UK chemical processing plant employing 202 people. The response rate was 84%. Structural equation modelling analyses (SEM) were performed using LISREL 8.80 (Jöreskog and Sörbom, 2006). Data were analysed following the two-stage process suggested by Anderson and Gerbing (1988). We used bootstrap techniques to estimate indirect (mediation) effects.

## **Results and conclusion**

We found support for a model that proposed employees' defining of important safety-related discretionary behaviours as part of their job (safety citizenship role definitions) partially mediates the effect of two important constructs that predict safety violations – work engagement and perceived management commitment to safety – thereby building on previous research by Hansez and Chmiel (2010). We also added to previous research by Turner, Chmiel and Walls (2005) by supporting the proposition that the relationship between job control and safety citizenship role definitions is mediated by work engagement and perceived management commitment to safety. Interestingly, we also found that the best-fit model supported the idea that work engagement also mediated the relationship between perceived management commitment to safety and safety citizenship role definitions.

These results reinforce the view that both safety-specific and non-safety specific processes are important when trying to promote safer working, and that the perspective on non-mandatory safety activities taken by employees may play an important part in these processes. Managers may affect safer working both by considering the resources jobs receive, and by conveying the importance and commitment they place on safety.

*Keywords: Voluntary safety activity, safety citizenship role definitions, safety violations, perceived management commitment to safety, job control, work engagement*

# Technical Session 9: Developing OSH competence

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## 1. Organisational safety professionals' work roles and safety management principles, based on an in-depth study of nine safety professionals' work in three companies

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**Teemu Reiman, Elina Pietikäinen** – VTT Technical Research Centre of Finland, Finland

Safety professionals have a key role in influencing the safety of an industrial organisation. Despite the number and significance of safety professionals, relatively little research attention has been paid to this professional group. Organisational safety professionals' work practices are poorly understood. One reason for this can be that safety professionals are a disintegrated group (e.g. in terms of education) that applies similarly disintegrated safety science (Le Coze, Pettersen, Reiman, in press, Hollnagel, in press) in practice. Thus, many safety professionals apply the principles that underlie their field of technical expertise, or can refer to lay theories and folk models of human behaviour in trying to influence attitudes or human errors. The object of these professionals' work also varies from individual attitudes and behaviour to collective practices, technology, or organisational arrangements, such as rules and procedures.

The role and knowledge requirements of safety professionals are complicated by the fact that they need to work in complex organisations with often-conflicting expectations and goals. Sometimes the object of the organisation's core task itself contains many uncertainties and potential hazards. Changes in the work environment can bring new uncertainties and change the risks the organisation faces in its work.

In order to understand the work of safety professionals, we need to understand what 'safety' is. The classical safety management paradigm views organisations as machine-like entities and emphasises procedural adherence, strict quality control, clear distribution of liabilities, and supervision of workers as the way to manage safety. Disappointments in the classical safety management paradigm, together with evolution in several scientific disciplines, have led to a view of safety as something more than the negation of risk. Safety can be viewed as an emergent property of the functioning of the entire sociotechnical system. This means that safety professionals' work should also be understood in the context of the entire sociotechnical system. Recent conceptualisations of these systems as complex adaptive systems (Plsek and Wilson, 2001; Woods *et al*, 2010; Dekker, 2011) have created further challenges in our understanding of how safety professionals should work in a manner that they would contribute to the overall safety, or even, the overall effectiveness of the system.

The 'Safety makers' research and development project started in June 2013 and lasts until autumn 2014. The project aims to provide new understanding on organisational safety professionals' work practices and to develop a model of organisational safety expertise. The study includes three case organisations in different safety-critical fields (nuclear-waste processing, petrochemical, construction) and a total of nine safety experts whose work will be studied for the duration of the project. All nine experts were interviewed with a semi-structured scheme during autumn 2013. Interviews lasted between two and three hours and provided a rich picture of the daily work practices and different work orientations of the nine professionals.

Three influencing mechanisms were defined that shape each expert's work role: personal orientation, organisation (core task, hazards, culture, current safety level), and safety knowledge. These together shape how the expert defines his role and on what kind of principles he bases his work practices.

A workshop was arranged in November 2013, during which these work orientations and the underlying principles were elaborated. A preliminary conceptualisation of safety management principles, created in several case studies of safety management in the nuclear and healthcare domains, was tested with the workshop participants. The four participants filled a framework describing the principles, and three of the five non-attending professionals returned the exercise later by either e-mail or paper format.

In February, a field diary method will be used to gather additional data on the safety professionals' daily work and practices for the duration of one week. Two additional workshops will be arranged during the project, and a final interview round of all nine safety professionals will be conducted in autumn 2014.

The presentation will focus on the underlying principles that the safety professionals rely on in their work, and the associated practices. The potential tensions between the different principles will be discussed as well as the influencing mechanisms in defining which principles are emphasised and which are not.

*Keywords: Safety management, safety professionals, safety practices, safety models*

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## 2. A framework for assessing and developing managers' safety competence

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**Sari Tappura, Noora Nenonen, Jouni Kivistö-Rahnasto** – Tampere University of Technology, Finland

Safety management is widely accepted as an essential managerial responsibility and managers' activities are seen as key factors when improving occupational safety and health. For example, safety research suggests that managers' safety activity is one of the most important aspects of a company's safety culture. Similarly, managers' positive attitudes towards safety programmes and enhancing the psychological environment are known to positively affect safety. Some studies suggest also that the supervisors, owing to their directive role, impact even more on safety than top managers or safety managers. At the same time, however, upper-management support for safety procedures is also seen as necessary. Thus, the safety awareness and competence of managers at all the organisational levels play a crucial role in managing and improving safety according to the safety policies and procedures of a company. The safety competence assessment and development of managers is one method of striving for high safety performance.

Competence entails a combination of knowledge, skills, attitudes, experience and behaviour deemed necessary to successfully perform one's work. In general, competence assessment and development refers to evaluation, updating, expanding or deepening one's competence at work. Competence assessment is one form of learning, and it provides guidance and support on learning needs. Generally,

competence development objectives and actions are based on the company's strategic objectives. When safety is a strategic factor, the safety competence of personnel should be developed accordingly. Since managers have a key role in implementing safety policies and procedures, their safety competence is crucial in order to achieve the strategic goals of the company. In this study, the focus is on managers' safety management and leadership competence, as well as their assessment and development. Managers' safety competence refers to the skills and knowledge needed to fulfil legislative and company-specific safety requirements as part of their managerial duties. In addition to managers' safety competence, a supportive organisational environment is important for these competencies to be effective.

The objective of this study is to discuss the ways of assessing and developing the safety management and leadership competence of managers. This study is part of the research project 'Safety leaders: Safety leadership, competence and commitment of managers'. This study proposes a safety competence assessment and development framework for managers. It is based on previous research and interviews with 18 line managers in a Finnish expert organisation. The framework consists of the following four phases: definition of managers' safety competence requirements; managers' self-assessment of safety competence; definition of organisational and personal safety competence development focus areas; and compilation of related safety competence development activities. When a safety competence assessment is carried out as a self-assessment, it guides managers to consider and reflect on their conceptions and actions. Thus, competence development is concurrent. However, organisational support, reflection and mentoring are also necessary for competence development. The framework takes general management competence development activities into account and complements them with existing activities.

In addition to identifying development needs, competence assessment may also be utilised for communicating managers' work targets and giving feedback on current competencies. Safety competence assessment and development provide managers with knowledge of their responsibilities and expectations, company-wide safety procedures, as well as tools for promoting safety. Furthermore, they influence managers' perceptions and attitudes toward safety, and encourage their commitment to safety.

*Keywords: Safety competence, safety leadership, competence assessment, competence development, safety management*

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### 3. Today's health and safety practitioner and learning at work: a discussion of work-based learning at the University of Portsmouth

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**Fiona Message, Euring John Bishop, Colin Gilbert-Wood, Michelle Juchau –**  
University of Portsmouth, UK

The role of the health and safety practitioner has evolved over the past 40 years. However, the vast majority of health and safety qualifications remain prescriptive and inflexible. Today's practitioners are not 'one size fits all' and employers are increasingly looking for professionals with more than just knowledge of health and safety.

For the last 23 years the University of Portsmouth has delivered a Work-based Learning degree, and in the last five years, numbers on the programme have grown rapidly. In 2012, 160 students graduated with either an undergraduate or master's degree. In the same year, the university moved its successful postgraduate suite of distance-learning health and safety courses into the department, providing the

opportunity to develop a new, more flexible qualification. The ethos behind the programme is that students design their own learning profile at master's level, with credit being awarded for evidential experience gained in the workplace.

At the first level, students study two taught units, ensuring key health and safety and management learning outcomes are achieved. Students then accrue credits (as required to achieve the award) by a series of work-based projects. For each one they must write a series of personalised learning outcomes, and the reports must show evidence that these have been met.

Experienced tutors are assigned to each student to help them deliver at an appropriate academic level. The document that their studies are based on is known as the learning contract. This is the first item they must submit for formal approval and assessment. The learning contract may be submitted for approval to one of several professional bodies.

This paper focuses on the advantages of gaining qualifications using the Learning at Work pathway for both the health and safety professional and their employer. For the health and safety professional, these include:

- their existing knowledge counts towards the degree award;
- they can gain a university qualification without having to take a career break;
- they can learn what they need when they need it;
- they can tailor the pace of learning to suit the demands on their time; and
- they can use their learning to gain professional accreditations, such as CMIOSH.

For the employers, advantages include:

- the education of their health and safety professionals can bring commercial and strategic awareness;
- commercially valuable work projects are part of the learning programme;
- the organisation gains knowledge of best practice and the latest technologies from work-based projects;
- university tutors provide new knowledge and advice, and encourage the development of transferable skills;
- better qualified staff enhance the organisation's leadership position; and
- the increased loyalty and motivation of employees as they develop their skills and confidence.

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## 4. Beyond competence to capability in the practices of occupational safety and health practitioners: a review of the current literature and implications for future practice

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**Paul D'Arcy, Alan Page – Middlesex University, UK**

### Introduction

The praxis of the safety and health practitioner is a diverse and complex one covering an eclectic range of disciplines. Additionally, practitioners need to be persuasive communicators from shop floor to boardroom. Practitioners also need to understand the business environment, both operational and cultural, to ensure that the most effective solutions can be implemented. This paper builds on the work of Pomeroy and Boyle (2010) and Couch *et al* (2011) to look at the necessary skills of a modern practitioner.



As a young profession, safety and health practitioners are still establishing themselves as professionals in their own right. Some commentators dispute whether we have reached a level of societal acceptance as a profession. Turner (1999), Erait (1994) and Rogers and Waters (2001) describe us as 'minor' or as a 'semi-profession'. Notwithstanding this, the media's recent focus on 'elf and safety' alongside the widely assumed rise in litigation leading to a 'compensation culture' (Young, 2010) have damaged the profession. However, each of these is a contested field. O'Neil/TUC (2013) questions the compensation culture, and Löftsted (2012) suggests that it is lay safety personnel poorly interpreting risk rather than advice from safety practitioners.

The legal position in the UK is for an employer to have access to health and safety assistance to ensure they are fully informed to enable them to comply with their statutory duties. This legislation therefore poses the questions: what level should this assistance be at? Who should provide this assistance? And what are the competencies of those providing the advice? This returns us to the question of the necessary skill set that the safety practitioner needs.

### **Aims and methodology**

The aim of this paper is to reflect on current literature, both grey and peer-reviewed, in relation to the competency and capability skill set of safety practitioners, and involved a comprehensive review and appraisal of the literature utilising the university's online 'Athens' account (the following search engines were explored: Cambridge Journals, Ebscohost, Emerald, Ingenta, Jstor, Medline, Oxford Journals, Sage journals, Science, Web of Science, Wiley online, together with grey literature through use of 'OpenSIGLE' 'opengrey' and 'Cadmus' systems, and use of non-academic literature, reports and articles produced by civil society, government and government agencies, and industry).

Applied search terms included 'competence capability', which then snowballed to include 'professionalism', 'continual professional education', and 'training', together with examination of key authors in this field. This review is part of a professional doctoral study that seeks to determine future training and educational needs for our profession through gap analysis.

### **Results**

The literature points to the fact that competence is a very complex and contentious field (Schon, 1983, Erait, 1994). For example, if one is technically very able but cannot pass this information on to others, are you competent? Likewise you can be a very good communicator but technically weak in a particular area of practice; again, are you competent? Alongside this, technical competency is time-bound and unless you actively update your skill set it decays over time.

The literature highlights the importance of having technical understanding with the right skills and knowledge to maximise performance (Pilbeam and Corbridge, 2003). However, technical competence does not sit in isolation of other skills. Fraser and Greenhalgh (2001) offer the view that practitioners need to be capable and that this is more than competence. In their view, competence is what individuals know or are able to do in terms of knowledge, skills and attitude, but capability is the extent to which individuals can adapt to change, generate new knowledge, and continue to improve their performance.

Other authors, including Stephenson (2003), are adamant that capability cannot be taught or passively assimilated. This is especially true in changing contexts, and where uncertainty arises. The individual's ability to solve problems, appraise the situation as a whole and prioritise issues to arrive at solutions in a complex environment, and reflect on and learn from the experience, marks out the capable over the competent.

The literature contends that there are four base areas that underpin safety and health professional competency and capability: knowledge, communication and advocacy skills; understanding of the business setting; personal management skills; and professional practice skills. These, in turn, are informed by training, experience, beliefs, culture and paradigm.

### Conclusion

The literature suggests that as an emergent profession, we and others remain unclear on the baseline skill set necessary to practise in the modern setting. Our education and CPD very much focuses on technical skills, and yet this is but one aspect to the professional practitioner's work. The question therefore remains: what does it mean to be competent and remain so.

As many job roles are now both super-complex (Barrett, 1999; and Berger, 2011) and inter-dependent (Brennan, 2005), they therefore require the practitioner to go beyond just the technical.

There appears to be a need for further study to examine and articulate the skills set needed for a capable safety practitioner, but there are emergent themes that include technical knowledge, wide communication abilities, business awareness, and professional skills.

*Keywords: Competence, capability, education, professionalism and practitioner*

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## 5. Using safety knowledge – how predictable are accidents and where does competence fit in?

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### Martijn Mud, Cornelis Hollaar – RPS Ltd, Netherlands

With the detailed causal analysis of more than 24,667 serious occupational accidents causing 25,473 victims over a period of 13 years, a substantial Dutch occupational accident database has been built [RIVM, 2013]. Using public software, these accidents are visualised as accident scenarios in 36 different models. These models are referred to as bowties, consisting of preventive, controlling, and mitigating barrier functions and an undesired centre event (such as fall from scaffold). The accident paths can be analysed to find trends and common patterns. For instance, common patterns in the underlying causes of barrier failures are found by analysing their influence on barriers and accident occurrence, respectively.

Safety barriers, in this context, refer to measures designed to prevent, control or mitigate undesired events. Barrier systems describe how a barrier function is realised or executed. For example: 'Prevention of entry into a danger zone' is a barrier (function). Physical barriers, such as walls, gates and doors, are also barrier systems. Barrier systems may range from a single technical system (e.g. a door) to a complex technical human system (e.g. steering a car).

Recently, the average exposure to hazard and state of barriers in the Netherlands was estimated using questionnaires and a representative sample of employees [RIVM, 2012]. By estimating the exposures to the different types of accidents, and then dividing the number of barrier failures by exposure, occupational accident frequencies were calculated. An occupational-risk model was developed from this data – ORM [RIVM, 2008]. On a national scale and in a stable environment, occupational accidents had become predictable.

However, barriers are not static. Barriers do not always fulfil their function to the same adequacy, especially in the dynamic circumstances of an everyday work floor. Indeed, barrier effectiveness is dependent on several incident factors. For example, the effectiveness of fall protection depends on the workers' competence and attitude to use it. Furthermore, whether a barrier functions effectively, is dependent on whether the barrier function is provided, used, maintained and monitored.

Fortunately, organisations, teams and individuals are, to some extent, able to cope with this dynamic behaviour of barriers. Eight management delivery systems are identified that influence a barrier's effectiveness, one of which is competence. Competence, on an organisational as well as individual level, is a key ingredient for barriers to be able to fulfil their safety function when required. In order to recover failing barriers, these failures need to be detected, diagnosed and responded to before they lead to undesired events.

From the database analysis, the relative occurrence of competence failure in relation to barrier failure, and, subsequently, accident occurrence, can be obtained for specific accident scenarios. For example, the number of accidents with competence as a failing factor for operating a machine can be derived from the database.

Still unclear is in what way competence influences barrier functioning. For example, competence to provide proper physical machine guarding is different to competence needed to supervise emergency response or to use personal fall protection. Clarity on this relationship would be beneficial to provide more focus on education and training, thus allowing a more efficient use of resources currently spent by organisations in these areas. This topic is investigated using the RIVM database, by determining the relative contribution of competence on the failure of the provision, use, maintenance and supervision of barriers.

Further analysis into the way competence influences barrier functioning is done by unravelling the complexity of barriers using classification methods proposed in literature. It is investigated whether there are differences in the influence of competence on functioning between barriers of preventing, controlling, and mitigating functions (Sklet, 2009). Likewise, the influence of competence on the barrier sub-functions (Hale, 2005) of detection, diagnosis and response is investigated.

The following research questions are also investigated:

- Do barrier failure rates vary for barrier type?
- How relevant is lack of competence as an underlying cause of accidents?
- Does this vary for industrial sector?
- What different types of competence can be identified, and how do they relate to the different types of barriers?
- What risk reduction can be expected if we optimise the aspect competence?

The RIVM database with 24,667 serious occupational accidents is used in an attempt to provide answers to the above questions. Examples from the database are given for clarification.

*Keywords: Occupational accidents, bowties, barriers, direct causes, underlying causes, risk, competence, barrier effectiveness.*

# TECHNICAL SESSIONS TS10–TS12

## Thursday 02 October, 13.45–15.15

### Technical Session 10: Competence workshop

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#### 1. Developing a global framework for the training and certification of safety and health practitioners: the INSHPO initiative

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**Andrew Hale** – HASTAM, UK / Ex-chair of the Certification Committee of the European Network of Safety & Health Professional Organisations (ENSHPO); **Pam Pryor** – Australian OHS Education Accreditation Board, Australia; **Dennis Hudson** – American Society of Safety Engineers, USA

Since its inception in 2001 INSHPO (International Network of Safety and Health Practitioner Organisations – [www.inshpo.org](http://www.inshpo.org)) has grown from three to 14 members worldwide, and includes the European Network of Safety & Health Professional Organisations (ENSHPO), which itself has another 21 national members. One of the main objectives of INSHPO has been to introduce a global framework of competency for OSH practitioners. This work builds on more than three decades of development concerning the harmonisation at European and international levels of the role and functions, education, training, and certification of these professionals, which is described in the papers by Hale and Pryor, also submitted to this conference.

This paper will present the results of a number of pieces of work carried out under the auspices of INSHPO in developing this global framework. These are:

- A study (Hale, 2013) of the way in which a range of national professional associations and ENSHPO itself define the profession and its role and education. This led to a framework defining three aspects that need to be covered, but which are not consistently covered by every country: the tasks which the professional/practitioner must be able to carry out; the learning outcomes of the experience and training, equipping that person to perform those tasks; and the underlying knowledge, skills and attitudes that need to be imparted by that training and experience.
- Agreement on a framework of tasks and functions of the generalist OSH professional – a role at strategic level for those with a bachelor's or master's level university education (or its equivalent). This is based on the work done by ENSHPO in the EU Safe project ([www.eusafe.org/index.php/en/](http://www.eusafe.org/index.php/en/)) and on the documents developed by a number of the national INSHPO member organisations. The framework defines seven dimensions of generic tasks, divided into 40 domains.
- A positioning of the generalist OSH professional in relation to the members of other professional groups concerned, usually, with deeper but narrower aspects of OSH, such as occupational hygiene, occupational medicine, ergonomics, physiotherapy, occupational psychology, environmental management, and emergency response.

- A framework of knowledge, skill and attitudes under six generic headings needed to carry out the tasks and functions, covering the core areas of understanding of hazards and risks, and of their control, OSH management, professional functioning, and the underlying technical, behavioural and management disciplines. These generic headings are broken down into 31 areas of knowledge and 11 of skills.
- A framework for the certification and registration processes to assess the education, training, experience and professional conduct.
- A study looking at whether there is documented proof of the value of the OSH professional or practitioner in the research or professional literature (Borys in preparation).

The frameworks need to be validated by submission to, and critical testing by, the national INSHPO members and their advisory boards and committees. They also need to be completed by the consideration of a technician or practitioner-level task and function, and related competence, at an implementation and compliance level in support of the safety professional. The project has also, so far, skipped the development of learning outcomes as of less importance than the topics covered.

*Keywords: Training, certification, globalisation*

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## 2. International harmonisation of qualifications for the occupational safety and health professional

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**Andrew Hale** – HASTAM, UK/Chair of the Certification Committee of the European Network of Safety & Health Professional Organisations (ENSHPO)/Emeritus Professor of Safety Science, Delft University of Technology, Netherlands

The profession of occupational safety and health (OSH) has grown up over the last half century into a discipline employing many hundreds of thousands of practitioners worldwide. Their level of basic education, their training in OSH, and their professional experience vary enormously from country to country, as does the development of professional associations and legal requirements governing their training and regulating their practice. Since the 1970s there has been a concerted effort to analyse and understand the differences between countries in those developments. This started in Europe with workshops attended by higher-education establishments developing graduate and post-graduate level training for safety professionals and researchers in five European countries. The research line was taken up, particularly in the Nordic countries, resulting in, among other developments, the establishment of the Working on Safety Network and its biennial conferences. The safety-professional training line was picked up at European level by the International Social Security Association (ISSA) in the 1980s. It was progressed from the 1990s by ENSHPO, which is interested both in the role of the OSH professionals in EU countries and beyond, and in the tasks to be regarded as core functions. These organisations carried out survey work to collect national information on the regulatory and professional requirements for training and certification. ENSHPO also collected data on the role and function of safety professionals across 12 EU countries in order to understand where the core of the safety professional role lay, and whether that was comparable across different countries as a basis for harmonisation. This formed the basis for the development of two ENSHPO voluntary certification standards at safety manager and safety technician levels. This raised interest in non-European countries, three of which also applied versions of the ENSHPO questionnaire. From 2010, a European project called EUSafe progressed the linking of task

descriptions to learning outcomes. The latest initiative, at a still broader level, by INSHPO, has brought in countries in North America and the Pacific Rim to develop and try to agree a global framework for the education, training and certification of safety practitioners.

This paper will describe the history of these developments in more detail, in order to draw out the issues that have arisen and have been required to be resolved, to make progress in this response to the globalisation of OSH and risk control. The issues include: the distinction between generalist and specialist OSH advisors; the relationship with other OSH professional groups; the need to distinguish between graduate-level safety managers and technician-level OSH staff; the extension or shift from technical and legal knowledge to human factors and OSH management and culture competences; national differences in the history and role of the professionals; and differences in the roles played by government regulators and professional bodies in their regulation.

This paper is designed to be presented together with two other papers on the Australian developments around professional education (Pryor), and the results of the INSHPO development of an international framework for the OSH professional training and certification.

*Keywords: Training, certification, globalisation*

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### 3. Accredited OHS professional education: a step-change for OHS capability

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**Pam Pryor** – Australian OHS Education Accreditation Board, Australia

In the last two years Australia has seen a step-change in OHS professional education with the implementation of the OHS regulator-funded OHS Body of Knowledge project. This project resulted in the development and publication of the OHS Body of Knowledge, accreditation of university-level OHS professional education programmes, and certification of OHS professionals and practitioners.

The OHS Body of Knowledge for generalist OHS professionals is achieving recognition within Australia and internationally. Initially developed as an edited e-book, written by acknowledged Australian specialists, the OHS Body of Knowledge takes a conceptual approach to describe the knowledge with which the generalist OHS professional should be able to engage to provide a basis for understanding the aetiology and control of work-related fatality, injury disease and ill health. The development of later chapters has taken a more inclusive approach, with the chapter structure being determined by a topic-specific technical panel. The chapters themselves are frequently the result of collaborative writing on the implications for practice that are identified through workshops and focus groups.

Professional accreditation for university-level OHS education was introduced in 2012. To date, ten programmes have been accredited across seven universities, with programmes from a further three universities being considered. Coincidentally, accreditation of OHS professional education has been implemented at the same time as structural changes in the quality standards for universities and changes in the Australian Qualification Framework. This has presented significant opportunities. Standards for accreditation of OHS professional education programmes not only require that programme content reflects the OHS Body of Knowledge but that the programme meets specific educational requirements. While these educational standards reflect the national standards for universities they have specific requirements relative to OHS programmes.

Commencing with a brief description of the rationale, development and implementation of the overall OHS Body of Knowledge project, this paper focuses on the OHS Body of Knowledge itself and accreditation of OHS professional education. The paper provides a discussion on competence compared with capability. It then draws on the results of accreditation assessments and a survey of universities to describe the impact of the OHS Body of Knowledge and programme accreditation on Australian OHS professional education. Both OHS and educational perspectives are considered. The paper concludes with an evaluation of the contribution of the OHS Body of Knowledge and programme accreditation to the capability outcomes of the Australian Work Health and Safety Strategy for 2012-22, with an extrapolation to potential lessons for other countries.

While this paper is submitted as a standalone presentation, it is intended that it is one of a series of three papers, with the other two papers examining the development of harmonisation of qualifications and certification over the last three decades (Hale and Pryor), and the work being undertaken by the INSHPO on a global framework for OHS practice (Hale, Pryor and Hudson). It is proposed that these three papers provide the basis for a workshop to explore international opportunities from these three activities.

*Keywords: Education, accreditation, body of knowledge, professional, competence, capability.*

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## 4. Preparing graduate students to be HSE professionals

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**Jean-Luc Wybo, Wim Van Wassenhove – Mines Paristech / CRC, France**

The work of safety officers in industrial companies is a complex mix of reactive tasks requiring a fast response and more analytical tasks needing analyses. Moreover, performing this job means being able to engage in dialogue with operators in the field and with top managers in headquarters, and to drive, in parallel, many different tasks at the strategic, tactical and operational levels.

Graduate students in engineering and management own academic knowledge and practical skills in a domain of expertise, such as mechanical engineering, chemistry, construction, electronics, human resources, accounting, etc. Some technical universities include safety curricula, for instance, in chemical engineering (Perrin and Laurent, 2008). Most universities and engineering schools provide students with management courses and organise internships in companies, but these students are not prepared to endorse the duties and responsibilities of a risk officer as their first job after their graduation.

There is a long history of public bodies training engineers to safety in the Netherlands since the 19th century (Swuste *et al*, 2010), and in the US since the Second World War (Heinrich, 1956). The first known postgraduate programme in safety, health and environment was launched in the Netherlands in 1989 (Hale and Kroes, 1997). Azares and Swuste (2012) propose a survey of postgraduate courses in Europe aimed at training safety professionals.

Education of future safety professionals follows the general trends of safety: focusing on reliability and technological improvements in the early 20th century, safety concerns were extended to human behaviour and, more recently, to organisational aspects. These evolutions were also translated in national and international legal frameworks to ensure prevention of accidents, protection of populations and the environment, and other values at stake. Chang *et al* (2012) propose a competency model of safety professionals.

For years, industrial companies offered safety officer jobs to experienced people who had a proven success in management positions, especially when this experience was gained in production or



maintenance departments. The increasing complexity of companies acting in many different countries, as players of a network of stakeholders and subcontractors, makes this choice less efficient.

To face these challenges, companies urgently need to hire competent people to manage health, safety and environment protection, cope with restrictive legal frameworks, and preserve their image in the public that is increasingly more concerned about industrial risks. This opens opportunities for the new generations of postgraduate students: "An academic qualification is regarded essential, since those specialists must be capable to address new problems by applying knowledge and skills to situations not previously encountered." (Azares and Swuste, 2012).

In this paper, we present an analysis of missions, tasks and experience of a number of French safety officers and HSE managers, from which we identified the present and future roles, missions and required skills of a safety officer. This analysis was then used to define a postgraduate programme aimed at providing students with the required knowledge, know-how and attitudes to succeed as safety officers in industrial, consultancy and insurance companies.

This programme covers six complementary domains: legal and normative framework; risk analysis methods and tools; safety management systems; human and organisational aspects; leadership; and emergency and crisis management. It is composed of lectures provided by faculty members and professionals, case studies, and a set of field projects, during which the group of students has to fulfil real missions provided by companies. The programme also includes a six-month internship in a company, during which the student is playing the role of junior safety officer under the supervision of a manager in the company and a member of the faculty.

Nowadays, most companies operate at a global scale in different countries. Safety officers and managers, as other managers, need to work in an international context, with colleagues from different backgrounds and cultures.

To prepare our students for this challenging environment, we select candidates from different countries and backgrounds, and we balance these differences in relatively small cohorts of 15 to 20 students. This intercultural group gives each student opportunities to work with different skills and cultures in teams varying from one project to the next. To conclude, we present the results of this programme over a 10-year period.

*Keywords: Safety, education, postgraduate students, cultural differences*

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## 5. Building an OSH competency framework – analysis of conceptualisation

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**Luise Vassie, Jane White – IOSH, UK**

This presentation seeks to explore the need for a competent OSH profession, how best to achieve this, and what we mean by a competency framework. In the main, it looks at the analysis of conceptualisation, how the concept of a competency framework has evolved during its development, and a reflection of creating a model with which professionals can engage.

Competence and competency are both words used to describe an outcome that is a required behaviour within a job role. However, competence is more usually used when describing a basic minimum level of job behaviour, and competency would be more usually understood to be a description of performance excellence. The development of a true competency framework should support this journey of an individual OSH professional to achieve excellence.

A competency framework is a model that broadly defines the blueprint for 'excellent' performance within an organisation or sector. It refers to a complete collection of skills and behaviours required by an individual to do their job (Boyatzis, 1982), and includes information on how the individual goes about their task and the expected outcomes.

Competency frameworks are now an accepted part of modern people management (Rankin, 2004). How in-depth they should be is a matter of subjectivity. IOSH argues that the framework should represent a 3D model, not only looking at skills specific to job role and industry but also focusing on the so-called 'softer' skill sets of management, leadership and communication, to name a few. This is a wide-angle lens that incorporates the behaviours and attributes of the person. In terms of specific people management interventions, employers could consider integrating the engaging management competencies into a range of practices and processes that they use to define and develop management competence (Lewis *et al*, 2011).

The generic framework would consist of a number of competencies, which can be generically applied to a broad number of roles within the organisation or sector. Each of these competencies is then defined in a way that makes them relevant to the organisation or sector, using language that is clear enough to ensure that everyone has a common understanding of what 'excellent' job behaviour looks like within the generic context. This common understanding then becomes the benchmark against which the performance of an individual, team, project, or even entire organisation, can be assessed.<sup>1</sup> IOSH proposes that an effective framework goes much further than this.

On our journey to explore and develop the framework it has been a necessary part of the process to re-evaluate our goals against the needs of the profession and external stakeholders. For example, during numerous workshops held with high-level OSH professionals and stakeholders it has often been difficult for them to conceptualise the framework. We have often found that participants will give examples of frameworks they are working toward or have developed for other specific tasks. This has been interesting given the ideational qualities of conceptualisation, where conceptualisation is the construction of world knowledge, including 'social knowledge' of people, objects, events, processes, and states of affairs in the world. Furthermore, "any ideology is a conceptual system of a particular kind" (Lakoff, 1996: 37). It is proving vitally important that as the framework grows, it meets the demands and realities of those for whom it is being designed.

As the world's largest body of OSH professionals, the Chartered Institution of Occupational Safety and Health (IOSH) ensures professional standards of its members through an audited continuing professional development (CPD) system and its robust code of conduct. We also set entry standards in education, developing knowledge into the application of knowledge and, thus, competence. It is this level of rigour that gives IOSH its credibility and the world of work confidence in the profession. It is generally understood that competence is a combination of knowledge, skills and experience, and while the first of these can be assessed through formal examinations, the latter two pose a more substantial problem for bodies such as IOSH, which attempt to regulate levels of professional competence. It has been IOSH's policy for many years to seek, in addition to an accredited qualification that demonstrates knowledge, evidence of experience and skills to practise at the competence level defined by the membership structure.<sup>2</sup>

There are many different framework models but, in general, the more specific the framework is, regarding what must be done and what must be known, the more complicated the framework will be, because it must incorporate the many different permutations that will be applicable to different roles, sectors, experience and progress on the career ladder. It is the analysis of concept that will feed full circle into shaping the product.

That a clear and unequivocal OSH competency framework would benefit the world of work is undeniable. It can be said that the health and safety profession has been misrepresented and misunderstood for many years,<sup>3</sup> so the transparency of a robust framework will bring benefits not only for the individual but also for the employer, recruiter and the world of work as a whole.

IOSH is currently testing the premise with a series of strategic focus groups. The groups are designed to bring together leaders in our identified stakeholder groups in order to review the concept of a competency framework, consider what it needs to do, and confirm that IOSH is the viable option for delivery of a framework. This presentation will focus on the analysis of these interactions and their power to enhance and shape the way forward. Clearly there is a risk that while it is agreed that a framework is necessary, its impact will be far and wide-reaching. Work is being undertaken in many areas of OSH to define such competency standards. A unified and sympathetic approach to the needs of all stakeholders is essential and IOSH is central to the success of this mission.

*Keywords: Competency, framework, professional development, lifelong learning, training, development, IOSH, conceptualisation*

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<sup>2</sup> [www.iosh.co.uk/Books%20and%20resources/Negative%20image%20of%20health%20and%20safety](http://www.iosh.co.uk/Books%20and%20resources/Negative%20image%20of%20health%20and%20safety)

<sup>3</sup> [www.eusafe.org/attachments/article/368/2010\\_3541\\_FR\\_EUSAFE\\_pub\\_ENr.pdf](http://www.eusafe.org/attachments/article/368/2010_3541_FR_EUSAFE_pub_ENr.pdf)

# Technical Session 11: Safety – the business case

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## 1. Safety as an accounting object

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Jari Paranko, Sari Tappura, Noora Nenonen – Tampere University of Technology, Finland

Safety is a very popular issue in the business world nowadays. Safety-related functions in companies have increased significantly in the last 15 years. Companies have been recruited specialists in the field. To promote safety, a number of training courses and other activities have been organised. When input is increasing, it is natural that interest in outcome also increases. To be able to show the benefits of safety work, the economic effects should be evaluated more accurately. However, the research evaluating the economic effects of OHS interventions is still relatively sparse and the methodological quality of their economical evaluations is limited. More precise information on real costs is needed. In addition, the benefits should be seen in monetary value, in order to assess the profitability of an investment.

The main objective of this paper is to provide one opportunity to improve the quality of evaluations. In this paper, the profitability analysis model of safety investment is presented. The model is also piloted in three companies. Safety-card education is used as an example of safety investment. This study will only analyse impacts from a company's perspective; workers and community are excluded. This study is part of a Finnish multidisciplinary research project, Safety Value, which aims to promote economic measurement and indicators of safety.

The key elements of the model are the ROA-calculation and the capacity model. The current net sales and profitability are based on a certain capacity. Investment's impact on the profitability takes place through changes in the net capacity.

Decision-making is a reasoning or emotional process that can be rational or irrational, and can be based on explicit reasoning or tacit assumptions. An investment decision is one example of a decision-making process. If an investment decision follows the capital budgeting process presented widely in the literature, it is assumed that decision follows a logical process that has a structured approach. If intuitive decision-making is used instead of a structured approach, experts follow a recognition-primed decision approach to fit a set of indicators into the expert's experience. Action can be taken immediately without weighing alternatives. In a structured approach, financial objectives and decision criteria may either be used or not. If financial decision criteria are used, the process should be supported by evaluation methods.

The presented model allows safety to be seen more broadly than as a simple cost factor. Instead of concentrating solely on the costs, the model also allows users to take into account income and capital turnover. The model received very positive feedback from the case company. The key choices of the model got special thanks. The model is currently the easiest to use for analysis to take place at the company level. The next development version of the capacity model will define net capacity as a combination of machine and staff capacity. Usability of the model is not limited to safety investments, but is universal. It is also good to remember that there are a lot of excellent ways of making an investment decision; using financial evaluation methods is only one of them.

*Keywords: Profitability, ROA, safety, safety intervention, OH&S, capacity model, safety card system*

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## 2. Proactive occupational safety and health management: promoting good health and good business

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**Cheryl Haslam, Jane O'Hara, Aadil Kazi, Ricardo Twumasi, Roger Haslam –**  
Loughborough University, UK

This research assessed the impact of organisational approaches to occupational safety and health (OSH) management on organisational performance, safety climate, employee attitudes, and health and wellbeing. The research was conducted in 31 case-study organisations, covering small, medium and large organisations across a range of industrial sectors. The sectors included: construction; manufacturing; education; utilities; public administration and defence; health and social care; real estate; renting and business activities; and other community, social and personal service activities.

The first part of the study comprised 78 interviews with health and safety personnel, company directors, and worker representatives from the participating organisations. The study employed a 'triangulation' approach, whereby different stakeholders in each organisation were interviewed to establish a realistic assessment of the organisation's approach to OSH management. In addition to generating rich qualitative data on OSH management and examples of good practice, the results were used to categorise the organisations according to their approaches to OSH management, using the continuous improvement cycle (CIC) model (Budworth and Khan, 2003). This model helps identify organisations or individuals in terms of their approach to health and safety, and describes three main types: 'yet to be fully engaged', the 'complier' and the 'very good'. The last of these categories identifies organisations most proactive in terms of their approach to OSH management. Five of the 31 organisations in this study were categorised as 'yet to be fully engaged', 13 were categorised as 'complier', and 13 were placed in the 'very good' category.

This categorisation of the organisations allowed an investigation of the impact of OSH management on organisational performance and employee outcomes. A cross-sectional survey of employees from these organisations (generating a sample of 2067 employees) looked at the impact of company size, industrial sector, and approach to OSH management, on indicators of organisational performance, and employee attitudes and health outcomes. A structured questionnaire included items to assess: demographic characteristics; organisation and job tenure; job satisfaction; organisational commitment; intention to quit and job motivation; self-reported absence; performance; and work-related ill health. Employee health and wellbeing were assessed using the SF-36 health questionnaire and safety climate was measured using the safety climate assessment tool, which assesses nine dimensions of safety climate.

Public-sector employees reported lower safety climate perceptions and more work-related illnesses compared with private-sector employees. In terms of industrial-sector comparisons, employees in the construction industry showed the highest levels of general health, safety climate, organisational commitment, and self-reported job performance. Employees in the utilities, real-estate renting and business activities sectors also reported high levels of self-reported health and safety climate perceptions, and positive organisational attitudes. Large organisations reported higher staff-absence rates, yet employees in SMEs reported higher levels of work-related illnesses. Organisations adopting a proactive approach to OSH management reported higher profit margins and lower accident rates.

With regard to the impact of OSH management on employees, 'very good' organisations were found to show more positive safety climate perceptions across eight out of the nine safety climate dimensions.

Employees in organisations with ‘very good’ OSH management were significantly more committed to their organisations and showed greater job satisfaction than employees in organisations categorised as ‘yet to be fully engaged/complier’. Positive safety climate perceptions and organisational attitudes were found to be associated with better self-reported physical and mental health.

*This research was funded by IOSH.*

*Keywords: Safety management, safety culture, organisational performance, employee health and wellbeing*

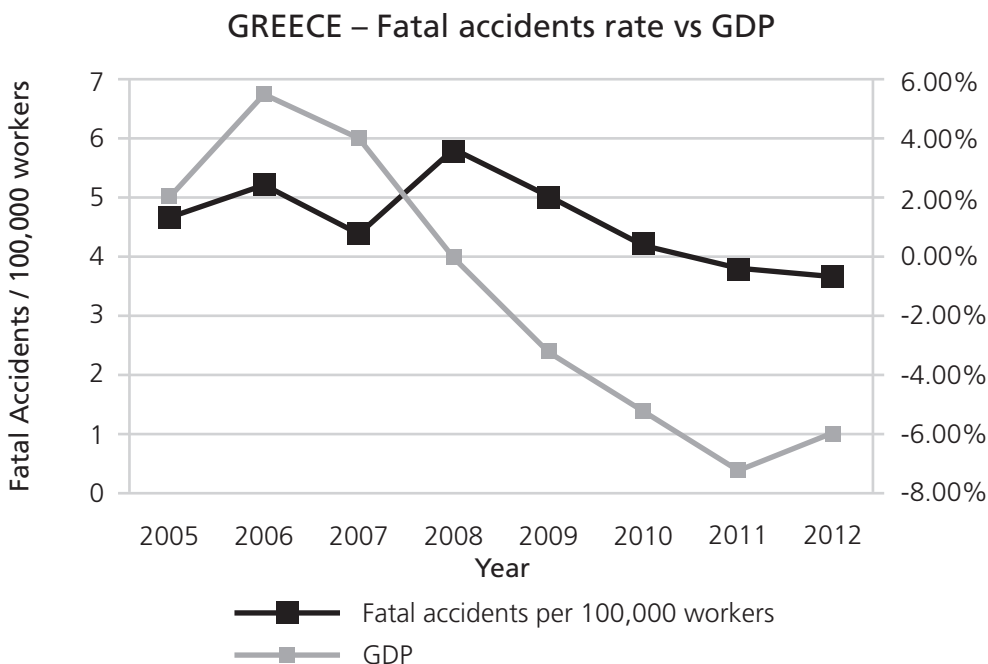
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### 3. OSH levelling during economic slowdown – the Greek paradigm and two conceptual models

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**Ioannis Anyfantis, Alexandros Karageorgiou – Ministry of Labour, Greece**

During periods of economic slowdown significant pressure is put on the labour market and working conditions, while occupational safety and health (OSH) is crash-tested. Areas such as training and purchasing of new work equipment and technologies are mainly affected. By analysing the economic values of most European countries for the last few years, during the different phases of economic cycles, it could be argued that accident rates are closely related to GDP. Thus, in periods of reduced economic activity, occupational accidents decrease (pro-cyclical effects). These can be confirmed by the Greek case, since Greece was probably the country most hit by recession (2008), leading to austerity measures for strong and sustained fiscal consolidation and deep structural reforms. Data analysis indicates an apparent pro-cyclical correlation between a country’s gross domestic product (GDP) and its accident rate, with a corresponding phase shift (time lag) representing the required time needed for adaptation.



**Figure 1: Fatal accidents per 100,000 workers vs GDP in Greece**

Additionally, new risk factors such as employment risks and industrial risks are introduced, and levels of perceived work intensity have risen among the workforce. Employees are willing to accept more workload and longer working hours in order to keep their job. Crisis usually becomes an excuse for non-compliance with labour standards and an argument to demand workers accept lower standards of working conditions. The situation was made worse after the changes in labour legislation that led to a dramatic increase of flexible employment agreements, while undeclared labour has taken very troublesome dimensions and forms in an expanding recession environment.

Moreover, research work shows the clear implications of the economic crisis on the psychosocial health of workers. That has to be seriously taken into account since it has many implications, either in the short term, such as lost days at work (WHO), or in the long-term, such as cardiovascular diseases related to higher stress levels in the workplace. Other research studies indicate that relative risks of stress-related mental and physical disorders are twice as high among those experiencing job insecurity or overtime work, compared with those with secure work or regular working hours. However, companies with healthy economics and an established safety culture, in which workers' involvement is important, find the crisis as an opportunity to strengthen their move to a zero-accident approach.

An organisational system diagram/model can be drawn in order to represent and identify determinants, and interactions between determinants, that have an impact on OSH outcomes. According to the proposed model, OSH is lying on a mesh supported by eight determinants, which are interacting, adapting and defining OSH's level, flexibility and strength against pressure posed by external factors, such as recession. This model constitutes a safety net acting as an opposing force to any pressure placed on OSH. The eight major determinants interact with OSH and with each other, forming a dynamic system that is constantly changing and adapting. All playing the role of stakeholders, these are:

- employers' organisations;
- OSH management and economics in enterprises;
- employers' point of view on OSH;
- employees' organisations' point of view on OSH;
- employers' and employees' participation;
- public expenditure/sector;
- roles and resources of the National Labour Inspectorate (NLI); and
- legislation.

Each shareholder has to redefine its position as well as its relationship with the other shareholders, and, consequently, OSH, in order to reach a steady state that keeps OSH at an acceptable level despite the pressure. The density of the stakeholder network and centrality in the network influence the degree of OSH resistance to external forces.

The key to the mesh's stability is the NLI's position and relationship with each one of the stakeholders. It could be argued that this is the stakeholder that can strongly define the network, since it can effectively define relationships with all of the stakeholders. This can be done, for example, by regulatory surveillance and strong enforcement, or by raising the general public's awareness of OSH. Mass and social media provide an excellent opportunity for sharing information about OSH culture while taking advantage of the social amplification/attenuation theories regarding risk.

Also, more emphasis should be given to prevention rather than reaction. In crisis, workers experience the combined effects of the intensification and precariousness of their work. Working processes relating to safety, psychosocial risks at work, and ergonomics should be redefined. This should be done not only by strict enforcement but also by strengthening cooperation with social partners.



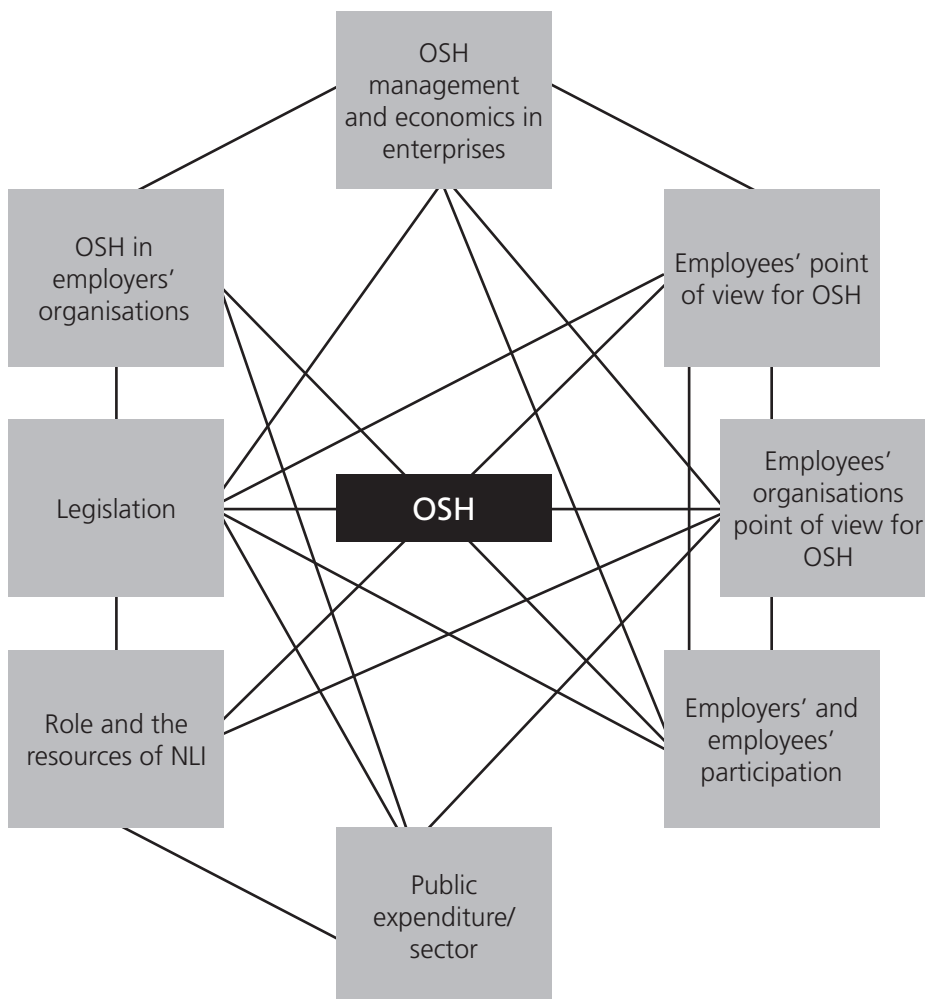
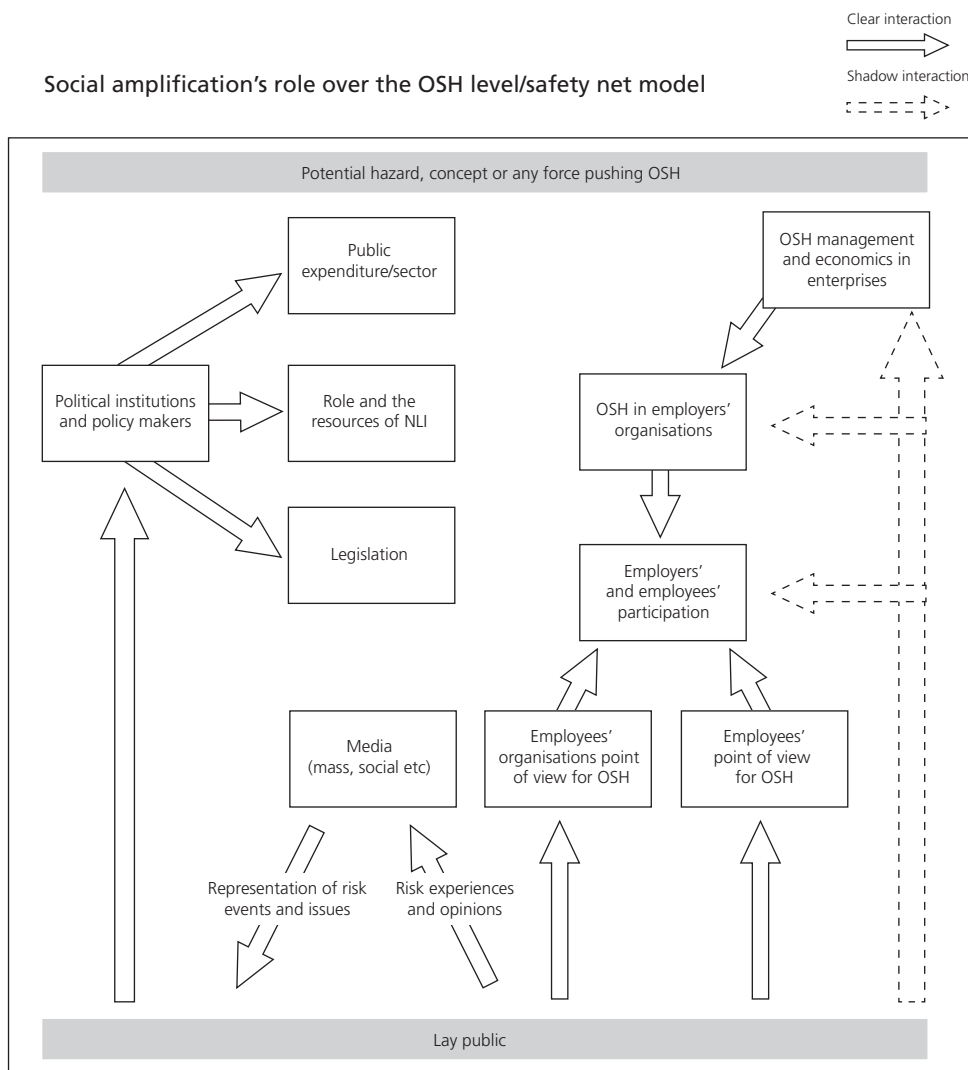


Figure 2: The safety net model

However, all these seem hard to achieve, especially in the case of small enterprises, which are more vulnerable owing to general multifaceted resources and/or OSH culture. The crisis intensifies the need to address the challenges of risk prevention in some enterprises, which, in some countries (like Greece), are the core of economic structure. It is also necessary to consider and remove administrative and/or bureaucratic burdens that restrict freedom of doing things more effectively.

Moreover, it could be argued that social amplification/attenuation of risk plays a significant role in regulating determinants' correlations and defining the network's strength. According to that theory, a station (e.g. a scientist, a firm, a journalist, an employee) that could also be one of the above-mentioned determinants, triggered by an event or a potential hazard, generates and transmits information via any communication channel (Web pages, social media, mass media, blogs, letters, direct conversations, etc.), and each one of the recipients engages in the amplification or attenuation process. In a simplified conceptual scheme, the following model of risk communication across the determinants could be drawn:



**Figure 3: Model of risk communication across the OSH-leveilling determinants**

This research proposes two conceptual models and the corresponding framework that may serve as a guide for ongoing efforts to develop, test and apply such a theory in countries that have been affected by economic slowdown.

The models are audited by the Greek paradigm. Each one of the determinants is analysed in order to find the way it is affected, as well as the actions taken in order to maintain the OSH level.

*Keywords: OSH-level model, economic slowdown, accident rates, safety-net model, communication of risk*

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## 4. Corporate managers' perceptions on safety and its value: an interview study of five internationally operating Finnish companies

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**Noora Nenonen** – Tampere University of Technology; **Päivi Hämäläinen, Jouko Heikkilä, Teemu Reiman** – VTT Technical Research Centre of Finland; **Sari Tappura** – Tampere University of Technology, Finland

### Introduction and objectives

A manager's active role is generally considered essential for managing and improving safety successfully. Managers, for example, have the position and powers to make decisions on safety investments. Moreover, they can influence the company's safety culture through their role and actions. Increased understanding about safety issues is considered to support a commitment to safety. The importance of information about costs and benefits of safety is often highlighted in order to motivate managers to take safety issues into account in decision-making. In addition, economic evaluations are needed to guide optimal safety-related decision-making; for example, when allocating limited resources to one safety investment over another.

The objective of this paper is to increase understanding of how corporate managers value safety and how they perceive the role of economic aspects and evaluations of safety. Moreover, we discuss how the approach corporate managers adopt towards safety and its value impacts and suits safety management in general, and in different economic situations.

### Materials and methods

In order to chart corporate managements' views of safety and economic aspects of safety, an interview study was carried out during spring 2013 as part of a larger study focusing on the financial value of safety. Twenty-three management representatives from the five Finnish industrial companies participating in the study were interviewed. The companies were large-scale enterprises employing between 4800 and 22,000-plus persons worldwide. The interviewees were CEOs, division managers, HR managers, production managers, and other managers. Between one and ten semi-structured interviews were conducted in each company. At the beginning of each interview, short questions regarding interviewees' background were asked (e.g. job title and description, years of work experience in the company). The major themes of the interviews were: first, management's view of safety, safety goals, and their measurement; and second, management's view of economic aspects of safety.

### Results

Based on the interviews, managers are well aware of the position of safety in the company and the main safety goals set. Safety is seen mainly as an important message – a promise to employees, which cannot be compromised. Traditional reactive indicators (accident and incident-based measures) are still emphasised as main indicators, although some proactive indicators were also mentioned.

In terms of the economic effects of safety, the interviewees often mentioned costs caused or avoided owing to accidents or safety investments. Some other impacts were also mentioned, including the impact of safety on company image as a business partner, employer and neighbour (to people living close to the company premises). According to the interviewees, a company with good safety performance is seen as a reliable service provider and partner. However, the interviewees were of the opinion that it is poor safety performance that particularly affects image (negatively), and that it is more difficult to stand out (positively) with a good safety performance because the level of safety is already good among competitors. A company needs to reach a certain safety level in order to be able to operate

and compete in the first place, particularly internationally. Other issues the interviewees mentioned related to economic impacts of safety, for example: impacts on the reliability and quality of operations; fluency of work and, hence, productivity; and impacts on competence as intellectual capital. A need to be able to show, more explicitly, the benefits of safety, indirect impacts of safety, and interconnections between safety and quality were mentioned in the interviews.

Costs – particularly, costs of accidents and safety investments – were measured and calculated as economic effects of safety. Savings and payback periods of safety investments were also estimated. Moreover, contrary to expectations, the interviewees saw little further needs related to measuring and calculating the economic effects of safety. Safety, itself, was considered as value. Safety is something that needs to be taken care of, and so should not necessarily be calculated as a price.

### Discussion

The interviewed managers approached safety strongly from the traditional viewpoint of reactive measurement of accidents and costs, and as an ethical principle, instead of seeing safety as part of business. Only a few specific needs for the economic evaluation of safety were perceived. It is possible that, in relation to safety issues, managers see their role, above all, with regard to personnel and the public, emphasising, hence, the ethical aspects and ethical valuation of safety. This may explain the hesitancy of the interviewees to discuss the financial value of safety.

It can be questioned, though, whether safety is included sufficiently in decision-making if it is only approached as a value in itself, and whether the situation would be different if managers had more and better tools to model economic aspects of safety. Economic evaluations could be useful, particularly in times of austerity when resources are scarce. However, as long as managers' approach to safety remains restricted and reactive, it is possible that the use of very simple calculation models feeds this narrow approach. Hence, it would be beneficial if safety were understood more widely, also recognising the economic aspect of safety. At the same time, the benefits and limitations of the tools for modelling economic aspects of safety need to be considered. The interviews were conducted during an economically difficult time in Europe when some of the interviewed companies also had economic problems. The effect of the economic situation on managers' perceptions of safety will be further discussed in the paper.

*Keywords: OH&S, safety management, economic evaluation, managers, value of safety*

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## 5. Safety and health at work as a factor of competitiveness of organisations

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### Miguel Corticeiro Neves – ISLA Leiria/ULHT Lisbon, Portugal

Occupational safety and health (OSH) is a key factor in the competitiveness of organisations, an issue that has been explored by research work in Portugal, covering the full range of enterprises and public administration.

According to Oliveira: “[A]ll entities must have the services of organised SHST. ... The existence of these services in the workplace, should be seen as a factor of productivity and competitiveness for businesses. The fundamental objectives of the implementation of these measures are, in particular, the reduction of accidents at work, and the consequent decrease of economic costs and, especially, human loss.” Companies operate nowadays in the context of an increasingly global market. Their competitiveness depends largely on the capacity and ability to adapt to new challenges. It's an important way of

learning, and improvement of working conditions and motivation, which are among these challenges, are some of the most important for the success of the company.

There is a consensus at different levels regarding the importance of the competitiveness of enterprises. On the one hand, productivity is, without doubt, the fundamental pillar for an organisation to be competitive. On the other hand, one can observe a set of signals that refer to induction potential of new management practices and qualitative renewal of specialisation profile in Portuguese business structure, incorporating one or more components of investment: quality systems, and safety and environmental management.

The population was divided into micro, small, medium-sized and large organisations, and was chosen by a stratified probability sample. By approximation, the number of companies studied was 899, which, in total, were sent about 18,800 messages.

Interviews with individuals involved in the world of work were also carried out, which influenced the conclusion that OSH is a theme that cuts across any type of organisation, and contributes an added value as a factor in competitiveness.

So far, no work of this nature has been carried out using the following assumptions:

- H1 – action of OSH services contributes to a decrease in occupational accidents;
- H2 – action of OSH services helps reduce absenteeism;
- H3 – the working conditions contribute to increased competitiveness; and
- H4 – OSH services are an investment, not a cost.

OSH services, when well implemented and suitable for the reality of organisations, contribute to the improvement of working conditions. As a result, work-related accidents and absenteeism decrease, resulting in increased productivity, so competitiveness is a factor of any organisation. It is concluded therefore that OSH, implemented by OSH departments, is a factor of competitiveness of any organisation, as demonstrated by the results of the investigation carried out and complemented by the views expressed in the interviews.

There is a direct correlation between working conditions and competitiveness of organisations. Organisations consider the costs associated with OSH to be an investment, which presupposes increased competitive advantage. The biggest and best companies to work for have OSH services, a factor for improvement of working conditions. They are also a factor for competitiveness: they increase productivity and therefore levels of financial turnover. Investing in internal services is also a competitive advantage. Maintaining high levels in the training of technicians helps to retain this advantage. This work also contributes to an overview of the organisational fabric Portuguese and the degree of implementation of OSH services.

*Keywords: OSH services, absenteeism, occupational accidents, competitiveness*

# Technical Session 12: Safety culture

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## 1. A learning environment for management safety culture training

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Robert Cram – Lancaster University, UK

In order to effectively manage safety performance, it is essential that line management has a clear understanding of the prevalent safety culture within the organisations they direct. Without effective insights, traditional safety management is a blunt instrument directed at perceived issues in the hope or expectation of some sort of successful outcome. This paper presents a novel approach in how to educate and train line management in measuring and understanding the safety culture of their organisations.

A common method of assessing safety culture is through the use of culture surveys. However, there is an abundance of research that suggests this approach is flawed. Many researchers have highlighted areas of significant concern with regard to the validity of the traditional survey approach.

Another key deficiency in the use of culture surveys is the time factor. A culture survey involves a great deal of time, effort and cost. Even if all of the issues relating to conventional safety culture surveys can be adequately addressed, there is no escaping the fact that discrete surveys only provide a snapshot of the safety culture of the organisation.

There is a case to be argued that deriving safety culture based on a single static survey of an organisation might, in fact, be counter-productive. The very fluidity of the typical organisation means that it is highly likely that the original initiatives will not be applicable to the continuously evolving entity. Short of running multiple surveys over extended time periods – an expensive and disruptive process – there is currently no realistic way to continually evaluate the impact of proactive measures on organisational safety culture.

Industry is therefore faced with a conundrum. On the one hand, safety culture is a major component in the ongoing drive toward a zero-accident environment, yet major deficiencies exist in the validity of the existing techniques of safety culture evaluation, and little, if anything, is available to educate and train management in how to measure and understand safety culture in their organisations. As one pre-eminent author observed: "If organisational culture, or some aspect of it, is to be measured, then complex and imaginative methods of assessment and analysis will be required. Questionnaires or similar measures will be inadequate to measure all aspects of organisational culture."

This paper describes the development of a new tool, which addresses the contemporaneous problems of measuring and evaluating corporate safety culture and communicating the knowledge and ability to senior management.

The tool described incorporates an accurate model of an organisation operating in a high-risk environment. Incorporated into the model is an immense quantity of data, which provides participants with deep insights into the culture of the entity they are 'managing', and enables them to see the real picture of the underlying safety culture.

Running on a bank of 16 computers, the learning environment accurately models the safety culture issues of an oil company of about 1000 people running for a continuous period of five years. Containing more than a quarter of a million data items, information is presented to participants on a 14-screen video wall, providing more than 50 pages of data for the participant to learn how to interpret. The tool runs the five years of the virtual company's life in a continuous eight-hour period. A fully functional e-mail system provides continuous input from the participant's senior management, as well as from the board of directors. Participants are required to respond to all requests for information and analysis as part of the process of demonstrating how well they have taken on board the lessons being taught, in respect of their awareness of their organisation's safety climate.

*Keywords: Safety culture, safety training, management training, safety culture measurement and evaluation*

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## 2. The relationships between organisational learning and safety

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**Ragnar Rosness** – SINTEF Technology and Society; **Jorunn Tharaldsen** – Petroleum Safety Authority; **Tor Olav Grøtan, Ranveig Tinmannsvik** – SINTEF Technology and Society; **Siri Wiig** – University of Stavanger, Norway

A major concern associated with organisations exposed to high risk is their ability to learn. Organisational learning, however, is mainly addressed in the aftermath of accidents, and recurrence of accidents with common characteristics is commonly explained by a “failure to learn”. It is thus tacitly assumed that learning is always good for safety. The literature on organisational learning and safety also seems to be mainly directed at management-initiated learning processes and learning that happens within the boundaries of a single organisation. Several issues are silent or under-communicated in the prevalent discourses on organisational learning and safety:

- Can organisational learning lead to impaired safety? Can drift of a sociotechnical system toward a less safe state be conceptualised as a learning process?
- Can a learning perspective improve our understanding of the functions of procedures and the dangers of trapping safety into compliance and rules? Can routine violations be conceptualised as a lack of ‘synchronisation’ between different learning processes? Can disciplinary approaches used to promote conformance with rules have undesired impacts on organisational learning processes?
- How can theories of power, culture and learning be used to analyse challenges related to collaboration and joint learning among people belonging to different professions or different subcultures?
- How can organisations learn without experiencing accidents? What can be learnt from normal operations, problem-solving and successful recovery?

This paper will discuss the relationships between organisational learning and safety, with a focus on the above issues, and derive implications for safety work and practitioners.

This study is anchored in a research and development project funded by the Petroleum Safety Authorities in Norway (PSA), which focuses on more proactive and ongoing organisational learning processes and learning in complex organisational interfaces involving multiple organisations. The study is based on a literature review on: i) organisational learning; ii) organisational safety and learning; and iii) organisational boundaries and inter-organisational relations, in regard to learning. More specifically,



in the discussion of the findings, we will draw on examples from research on major accidents, PSA's own audits and investigations, and address the following five topics: 1) learning and drift; 2) the danger of trapping learning and safety into compliance and rules; 3) the function of procedures; 4) the importance of managing learning through foresight, insight, oversight and hindsight; and 5) promoters and constraints on organisational learning.

The results of a literature search on organisational learning and safety showed that most of the research articles dealt with learning after major accidents or critical incidents. Also, there seems to be lack of research examining learning in project-based and inter-organisational contexts related to safety.

We outline an understanding of organisational learning as a process by which organisations and their sub-units change due to experience gained from normal operations, as well as from problem-solving, near-misses and accidents/incidents. Learning then involves complex sub-processes at different levels – individual, group, and organisational – but also across organisations and hierarchies. Such sub-processes may range from more spontaneous and tacit intuitions at the individual level, to institutionalisation through rules, systems and structures at the organisational and inter-organisational levels. Organisational learning does not, by definition, lead to improved safety. A group or an organisation may, for instance, learn to be more efficient and less safe.

We argue that drift into failure should be viewed as a learning process rather than as a failure to learn. The same processes of adaptability and variation can, thus, account for both success and failure. Both spontaneous and managed learning processes may lead to increased accident risk.

We also argue that the interplay between different learning processes is important for the safety outcome. Spontaneous learning processes at individual and group levels are not necessarily synchronised with learning by institutionalisation at the organisational and inter-organisational levels. Such lack of synchronisation may lead to discrepancies between formalised rules and practice, in particular, in organisations with extensive and detailed prescriptive rule systems. If management chooses to treat such discrepancies as violations to be eradicated through sanctions in order to promote compliance, then the likely result is that members of the organisation will find ways to disguise practices that deviate from the formal rules. Alternatively, blind compliance may result. An alternative management strategy would be to seek ways to bring local adaptations and institutionalised rules 'on speaking terms', based on the more realistic assumption that adaptations are often necessary to handle situations not covered by the institutionalised rule set, whereas some adaptations may lead to unacceptable risk levels. This implies that management has to create a climate in which their subordinates can safely reveal the local adaptations they make to handle variability in input, demands and environmental conditions.

The theory of model monopoly may be used to analyse challenges related to collaboration and joint learning among people belonging to different professions or different subcultures. This theory can also be used to open up discourses that are locked into a limited perspective and exclude the perspectives of other stakeholders.

We conclude that an analysis of the relationships between organisational learning and safety can lead to a richer understanding of issues that are central to safety work, such as drift, the functions of procedures, and the occurrence of violations. Such an analysis also allows us to derive implications for practical safety work.

A pamphlet presenting results from this work in a popular style is available in Norwegian and English.

We have identified a need for research on organisational learning and its relations to safety in contexts where: 1) interaction patterns, knowledge creation, and information processing involve intertwining of several organisational players; 2) intertwining of work tasks expands single organisational management systems, organisational identities, and goals; and 3) learning happens across business units and in multiple hierarchies.

*Keywords: Organisational learning, safety, culture, power, drift*

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### 3. Maturity models: a useful solution to assess current OHS management system

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**José Pedro Domingues, Paulo Sampaio, Pedro Arezes** – University of Minho, Portugal

Occupational health and safety management systems (OHSMS) are implemented worldwide and by an increasing number of companies. Usually this management sub-system is not the first one to be implemented and is seldom the only management sub-system implemented by a company. Therefore, the OHSMS performance is most appropriately assessed if one considers it within an integrated management system (IMS) and, usually co-existing, with a quality management sub-system (QMS) and/or an environmental management sub-system (EMS). Furthermore, OHSMS actions are often, if not always, constrained by quality and/or environmental requirements. The dynamics of complex systems, such as IMS, have been targeted by numerous researchers in different scientific domains. All of them pointed out that these systems are characterised by a non-linear behaviour and a large amount of variables often related to each other. Maturity models have been adopted to minimise our complexity perception over a truly complex phenomenon. In this sense, maturity models are tools based on a non-deterministic methodology, which enable the assessment by the identification of the most relevant variables that influence their outputs. Ideally, besides this identification, a maturity model should provide information concerning the qualitative and quantitative relationships between variables and how they affect the latent variable, i.e. the maturity level of the maturation object.

Regarding OHSMS (maturation object) assessment, one may assess it based solely on OHSMS indicators, but further improvement actions should also rely on the contributions of other implemented management sub-systems, thereby reflecting an integrated context. This fact reformulates the purpose of OHSMS within a company and demands a systemic vision by the OHSMS manager. Some other issues should be considered, too, such as the implementation of integrated indicators, audits and procedures, and the harmonisation through adoption of a common 'language' between the sub-systems. Some features concerning the intrinsic philosophy from each sub-system may be benchmarked for the remaining sub-systems, as the systematic risk approach that characterises the OHSMS. It is intended in this paper to report several maturity-model characteristics that enable such models to act as suitable tools for assessing management systems' maturity and, specifically, that of the OHSMS. Additionally, it is also intended to synthesise all the main features found in the literature review performed, namely: which are the key questions to consider prior to model definition; which limitations should be expected; the definition of the main relevant concepts, such as maturity, capability, maturation and maturation object; and the classification of existing maturity models. Finally, a maturity model enabling integrated management systems assessment will be presented, as well the main advantages of adopting this model, concerning OHSMS features. This model, based on front-office and back-office components, considers the key process agents (KPAs) identified through a systematic literature review, and by the conduct of several case studies of companies, as well as the qualitative and quantitative relationships between these variables and their contribution to the latent variable (IMS maturity level). Ultimately,

this model translates the OHS management sub-systems' current reality – namely, the fact that their implementation and daily management are not independent from other management sub-systems and their requirements.

*Keywords: OHSMS, maturity model, maturation, maturation object, maturity levels*

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## **4. How to engage company management to improve safety leadership: practical experiences of an actual intervention of a large energy provider in the Netherlands**

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**Sander Zwanikken, Anja Dijkman – AdviSafe Risk Management BV, Netherlands**

A Dutch energy provider with 4,000 employees, servicing 2.6 million households in the Netherlands with maintenance and renewal of electricity cables and gas pipes, noticed that, despite all efforts, safety performances were not improving. Employees did not follow rules in all situations, safety was not an overall priority, and too many incidents and accidents still happened. Therefore, in 2013 AdviSafe Risk Management BV was assigned to evaluate the current safety situation, the quality of the safety organisation, and the strengths and weaknesses of the safety culture of the company. Evaluation results were presented by AdviSafe in a roadmap for future improvement of the overall safety performances of the company.

In order to realise a successful transformation process (Kotter, 2007), we started with a workshop at top management level to identify possible causes for the current status quo and to set the safety ambitions for the coming years. In this workshop we addressed the importance of management commitment at all company levels of the energy provider. Following the outcomes of this workshop, our diagnosing method consisted of more than 40 semi-structured interviews, two group sessions, two observation days in the field, and extensive HSE document reviews focused on the three main pillars that set the safety situation in the company: human behavior/safety culture; safety management; and quality of the hardware.

In our findings we confronted management with differences between their earlier statements and our experiences in the field. From here, an integral roadmap on strategic, tactical and operational levels for further improvement was developed with the company's management. One of the first major interventions was a training programme for all company (middle) management. The training focused on sharing targets and expectations for safety improvement from top management, and offered concrete tools to fill in those expectations at all levels. Every training session was started and closed by a member of the board to show commitment for safety and to increase communication and trust between all levels of the organisation. Every employee was encouraged to formulate his own 'I-statements' for safety and to share experiences for working on the I-statements in the weeks following the workshops.

At this moment (first quarter 2014) all (middle) management employees are being trained. We will monitor the safety climate and behaviour, and the improvements frequently during the process (questionnaires, observation methods such as Elmeri, etc).

In our presentation we will present, in detail, our diagnosing qualitative method, the importance of the change management process around the diagnosing stage and the intervention stage, and the preliminary results of the interventions. Pitfalls, tips and tricks from practice are presented as learning points for future interventions and change processes for a company safety culture.

*Keywords: Safety management, engagement, intervention, safety culture, leadership, trust*

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## 5. The effect of working conditions and safety climate on the impact of personality on injury involvement. A longitudinal study in two male-dominated occupations

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**Kent Jacob Nielsen** – Department of Occupational Medicine, Herning Regional Hospital; **Claus D Hansen** – Aalborg University, Denmark

### Background

In psychology, personality traits are understood as stable and enduring personal characteristics – part of which may be biologically inherited and, for that reason, quite difficult to change – and postulated to have an impact on behaviour. It has been almost a century since it was first proposed that differences in such personality traits were the reason why some individuals were more prone to involvement in work-related injuries than others. However, this line of research has had a long and troubled history, which has led to sparse results with inconsistent, contradicting and inconclusive empirical evidence. These confusing results can partly be traced to two limitations in the previous studies: first of all, a lack of a coherent taxonomy has resulted in a wide variety of more or less comparable personality traits being measured. However, the emergence of the five-factor model, also known as the ‘Big Five’ (extraversion, neuroticism, conscientiousness, openness and agreeableness), has helped create a more coherent view of the area, as it has been widely accepted as a valid and reasonably generalisable taxonomy for personality structure. Secondly, previous research, with a very few exceptions, has been based on bivariate relationships between traits and injury involvement, without controlling for the effects of situational moderators, such as the nature of the work environment and the presence of restrictive (safety) climates. It would be expected that these well-established proximal antecedents of injuries would influence the relationship between an individual’s injury involvement and the more distal Big Five personality traits.

### Aim

The aim of the current study was to investigate the effect of working conditions and safety climate on the impact of the ‘Big Five’ personality traits and their involvement in occupational injuries. The hypothesis was that the association between personality traits and injury involvement would be modified by the level of the safety climate (high versus low) and the type of working conditions (routinised versus complex).

### Methods

Data for the analysis is taken from MARS, a panel study of workers in two male-dominated occupations in Denmark (n = 1842): a sample of ambulance workers that have quite complex and changing working conditions; and a sample of slaughterhouse workers working in a highly routinised environment. The 20-item version of the Mini-IPIP Five-Factor Model (Donellan *et al*, 2006) was used to measure the participants’ scores on the ‘Big Five’ personality factors. In addition, age, a measure of the safety climate at the participants’ workplace, and self-reported injuries were derived from the questionnaire. Logistic regression was used to analyse associations between the five personality factors measured in the first round of questionnaires and injuries reported at the second round 12 months later.

### Results

The results show that three personality factors are associated with injuries: extraversion, neuroticism and openness. Openness is consistently associated with a higher risk of injury involvement across conditions. However, the effects of extraversion and neuroticism are modified by working conditions and safety climate. Both are associated with high injury involvement if the safety climate is low and the working conditions are complex.

## Conclusion

Individual-level psychological differences are associated with higher injury involvement. While openness was consistently associated with higher injury involvement, job routinisation and the level of safety climate impacted on the association between injury involvement and neuroticism, and extroversion. Future research needs to explore further the relationship between personality, working conditions, safety climate, and injury involvement.

*Keywords: Big Five, ambulance workers, slaughterhouse workers*

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## 6. Safety-conscientious work environment and problem identification in high-reliability organisations. An exploratory study

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**Inmaculada Silla, Joaquin Navajas – CIEMAT-CISOT, Spain; Frank Guldenmund – Delft University of Technology, Netherlands**

In high-reliability organisations (e.g. chemical plants, nuclear power plants, air-traffic control) accidents cannot be explained based on either single or multiple causes. In other words, accidents are not caused by a coincidence of independent technical, human or organisational errors, but their interaction may result in a systematic migration of organisational behaviour toward the boundaries of safety. In this context, the identification of 'early signs' of potential undesired events has captured researchers' and practitioners' attention in high-reliability organisations. Organisations' ability to know how close they are to the boundaries of safety and to anticipate any undesirable event has become crucial.

Research on this topic has relevant practical implications for society since, in high-risk organisations, any system failure may cause relevant human, economical and environmental costs. In this context, recent theoretical developments emphasise the relevance of front-line employees' participation for better monitoring of operations and anticipating the undesirable. Moreover, several authors emphasise human behaviour as a source of anticipation and adaptation rather than a source of performance deviation or errors. Therefore, several international bodies have pointed out the need to promote employees' problem identification and a safety-conscientious work environment. Additionally, it is noteworthy that the success of many safety programmes relies on these preconditions.

To date, empirical research on problem identification and safety-conscientious work environment in the field of high-reliability organisations is scarce. The purpose of this study is to explore those factors that either support or are detrimental to problem identification and a safety-conscientious work environment. This study adopts a mixed-method approach combining both qualitative and quantitative data. A survey was administered, and several focus groups were conducted, addressing preconditions that enable problem identification and a safety conscientious work environment.

Qualitative findings showed that employees' accountability and inter-departmental relationships allows one to better understand problem identification and safety-conscientious work environment in high-reliability organisations. Quantitative data suggest that those organisations in which cooperation, supportive relations among work colleagues, performing at high levels, and individuals' growth are encouraged also experience greater problem identification and a safety conscientious work environment.

Findings have relevant theoretical and practical implications. Firstly, they cast light on some of the relevant factors to take into account when developing theoretical models that adopt a proactive

approach to safety. Secondly, problem identification and a safety-conscientious work environment are critical for organisational learning. Finally, these findings have a number of practical implications. It is noteworthy that many organisational policies and safety management programmes aimed at identifying 'early warning signs' or 'leading indicators' of safety degradation rest on participative approaches that allow front-line employees to identify those signs. In this context, research on those factors that contribute to problem identification and a safety-conscientious work environment has relevant practical implications for the success of these safety policies and management programmes. They also become crucial for organisational learning.

# TECHNICAL SESSIONS TS13–TS15

Thursday 02 October, 15.45–17.15

## Technical Session 13: Sector case studies: agriculture and fisheries

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### 1. Risk factors for occupational injuries among Norwegian farmers – does organisational safety matter?

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Kari Kjestveit – University of Stavanger/International Research Institute of Stavanger (IRIS); Kari Anne Holte – International Research Institute of Stavanger, Norway

This study addresses risk factors for injuries among Norwegian farmers through analysing how personal and workplace characteristics affect occupational-injury involvement.

Most Norwegian farmers are self-employed (Statistics Norway, 2012), though they often receive help from family and spouses (Logstein, 2012). Work at a farm, therefore, lacks the traditional employer-employee relationship, as well as a formal organisation. Furthermore, work in agriculture is regulated differently and less so than the work in other industries. Agriculture is also heavily dependent on external constraints, such as weather conditions and agricultural subsidies. During recent decades there have been some structural changes in this industry. The numbers of holdings, farmers and man-labour-years have all been reduced (Statistics Norway, 2010, 2013a). Yet, holdings are larger, more efficient and there is no overall reduction in the production of agricultural products (Statistics Norway, 2013b, 2010). This may have an impact on how the industry is organised, regarding each farmer's workload, number of employees, and degree of cooperation with other farmers.

Statistics have revealed the high risk of fatal agricultural accidents (the Norwegian Labour Inspection Authority, 2011). However, the injury statistics are insufficient to analyse the relationship between risk factors and occupational injuries, and there is a general need for more knowledge about the relationship between work conditions and injuries among Norwegian farmers. International studies have shown that handling animals, tractors and other machinery are the most frequent causes of injuries (Mattila *et al*, 2008; Erkal *et al*, 2008; Virtanen *et al*, 2003; Solomon, 2002), and these results correspond with the results of a Norwegian research report (Aas *et al*, 2011). Other risk factors for accidents are gender, age, physical health, and conditions of employment (Virtanen *et al*, 2003; Rautiainen *et al*, 2009; Sprince *et al*, 2003; Day *et al*, 2009; Horsburg *et al*, 2001; Hartman *et al*, 2004; Myers *et al*, 2009). High levels of stressors and stress symptoms are also suggested as risk factors for occupational injuries in agriculture (Glasscock *et al*, 2006). Examples of stressors are work overload/time pressure, role conflict, economic concerns, administrative burden, and unpredictability (*ibid*).

Available research gives us knowledge about the risk factors related to the individual characteristics and the type of work. However, we know less about the context in which the accidents occur – in this case, referred to as organisational factors. There is a need for in-depth research of agricultural injuries in order to understand their circumstances and identify the areas of influence through which these accidents can be prevented. A report about systematic work in relation to health, safety and environment (HSE)



issues in the case of fishermen pointed to professionalisation as a means for higher safety standards. Clear differences were found among the self-employed home-fishers and the larger boats with some employees, compared with the big boats, which are part of a ship owner's organisation. The latter had the highest degree of emphasis put on technical safety and HSE systems, compared with the lone fishers and smaller boats (Lie *et al*, 2005). A similar categorisation can be made with people working in agriculture, dividing into the following three groups: a) the lone farmer; b) the family farmer, working together with his/her spouse; and c) the 'professional farmer', who has one or more employees. Whether the farm is the only source of income or if the farmers are employed elsewhere may also be important for groups a and b. Based on these degrees of 'organisations', this study will focus on the relative importance of organisational factors in agriculture and discuss how injury risk in agriculture can be dealt with in terms of organisational safety.

Data were collected through a questionnaire survey sent to a net sample of 7441 farm owners in November 2012. The response rate was 40% (n = 2967). The respondents are found to be representative regarding age, geographical belonging, and type of production (Storstad *et al*, 2013). The questionnaire contains questions regarding: the farmer and his/her farm; working hours; employees; machinery; health and worries; and physical and psychosocial work environment. It also includes questions aimed at measuring safety climate, and asks farmers if they have been injured during work in the past 12 months.

The data will initially be described through t-tests, correlation analyses, and chi-squares. Thereafter, stepwise regression analyses will be conducted in order to reveal relationships between the different characteristics anticipated to influence injury risk. Being injured in the last 12 months will be set as an outcome variable. Predictors will be the organisational structures and safety climate. A preliminary hypothesis is that a high degree of organisational structure will positively affect the outcome (i.e. fewer injuries). Being an employer is anticipated to have most impact on the outcome compared with being a lone worker, owing to the former's formal commitments and higher safety awareness. Positive safety climate assessments are also anticipated to affect the outcome positively, as a mediator between the organisational structure and outcome. The results will be discussed regarding the importance of organisational safety and the following implications.

*Keywords: Agriculture, occupational injury, safety climate, organisational safety, regulation*

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## 2. Evaluation of a risk assessment and short training strategy to assist farmers to manage farm health and safety

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**John McNamara** – Teagasc – Agriculture and Food Development Authority; **Patrick Griffin** – Health and Safety Authority; **James Phelan, Jim Kinsella** – University College Dublin, Ireland

### Topic

This paper describes the evaluation of the pilot phase of a national initiative combining legislative and extension (i.e. provision of training and advice) approaches to assist farmers to effectively manage farm occupational safety and health (OSH).

The agriculture sector in Ireland has a poor health and safety record accounting for approximately 30% of workplace deaths, while about 7% are employed in the sector (Griffin, 2013). In a national survey a farm accident was reported to have occurred on 2.46% of farms, with 73% occurring to the farm operator (McNamara and Kinsella, 2012). Internationally, the agriculture sector has been ranked as an extremely hazardous occupation; for instance, in the United States, it is among the top three occupations with the highest injury rates (DeRoo and Rautiainen, 2000).

Thus, seeking approaches that improve the OSH record of the agriculture sector are urgently required but limited research has been conducted in this area (Rautiainen et al, 2008). However, as the structure of the sector is geographically dispersed and involves a high level of self-employment, OSH enforcement in this area is problematic (Mitchie et al, 2011). While little evidence has been found to indicate an OSH protective effect of educational approaches in the agriculture sector on their own (Rautiainen et al, 2008), the use of several approaches in combination offers possibilities to assist farmers to effectively manage OSH, and it deserves research consideration.

In Ireland, new safety, health and welfare at work legislation was introduced in Ireland in 2005 which permits the use of a risk assessment in association with a sector-specific code of practice to manage OSH. The Irish Health and Safety Authority, and Teagasc, the state agency responsible for provision of research, training and advice in the agriculture sector formed a joint prevention initiative to develop a code of practice for the agriculture sector and an associated risk assessment document (RAD). In the initial phase of the initiative, the RAD was devised and its utility evaluated in association with provision of short training. This paper describes farmers and facilitators' perceptions of the utility of the RAD and associated training, which were evaluated in the initiative's pilot phase. Further papers submitted to this conference provide information on: (1) implementation of OHS controls on farms following RAD completion; and (2) on accident occurrence associated with RAD completion and associated training and farm variables.

## Methods

Approximately 4,000 farmers participated in the pilot phase of the joint prevention initiative by attending a half-day training course on completing the pilot RAD. The RAD is principally composed of hazard-control sections and a section for listing necessary OSH actions. The hazard-control sections of the RAD provide relevant data on accident causes and associated pie charts and pictures. For each section, a list of possible OSH controls required are listed and a matrix format allows hazards to be identified for a range of farm activities and locations. The training provided was about 3.5 hours in duration and outlined OSH legal requirements, and accident and ill-health causes. All sections of the RAD were explained and participants were allowed time to consider controls specified in the RAD needed for their own farm. Following participation in RAD training, a sample of participants (n = 291) completed a questionnaire on the pilot RAD and the half-day training course. A further questionnaire was completed by Teagasc staff (n = 54), who facilitated training on their views of the utility of the training to farmers. Answers to questions were framed on a 5-point Likert-type scale (with 5 being the highest positive response), which allowed answers to be converted into a single score.

## Results

Farmer participants at training considered OSH management an important issue (score: 4.8). Regarding the RAD, farmers felt the number of questions in it was about right (4.0) and easy to understand (4.0). Both the use of pie charts to show accident data (4.4) and use of pictures to show controls (4.2) were considered to aid communication. Farmers intended to complete the RAD within two weeks of training (4.3). Regarding participation in training, farmers considered this worthwhile (4.5) and it assisted with their understanding of legal OSH duties (4.4). Training approaches that received high scores included use of accident-victim testimonials on DVD (4.6) and showing OSH controls on DVD (4.5); the approach that received the lowest rating was the level of discussion at training (3.9). Participants reported that training motivated them to implement OSH controls (4.5).

Among facilitators of training, their opinion that farmers consider OSH management as an important issue was lower than that of farmer participants (3.6). They considered that farmers found participation in RAD training worthwhile (score 4.3), that the RAD training course was well structured (4.2), and that participants completing the RAD at intervals during the training worked well (4.1). Training approaches that facilitators considered particularly worthwhile included use of accident-victim testimonials on DVD (4.3) and discussion on accidents (4.1). Facilitators considered that the training motivated farmers to implement controls (4.3).

### Conclusions

Farmer participants considered farm OSH to be an important management issue, but facilitators of RAD training had a lower opinion of the importance that farmers assign to this issue. Both farmer training participants and facilitators had a positive of the RAD and associated training, particularly the use of visual approaches. The data available suggests that use of the RAD at training motivated participants to implement the controls specified in the RAD.

*Keywords: Agriculture, safety, risk assessment, training*

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## 3. Severity of accidents in agriculture sector in Spain

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### Introduction

The agriculture sector is an important sector in the Spanish economy because of the high number of workers employed. In addition, workers of the sector are exposed to multiple risks: ergonomics; fall from height; trapping; loss of machinery control; environmental; noise exposure; vibrations; and biological or chemical risks. Although the importance of the cited risks is clear, the number of scientific research studies about the topic is especially low. Current research analyses all agriculture-sector accidents in Spain for the period between 2009 and 2012.

### Objective

The research objective is to obtain new insight into the likely causes of agriculture accidents in Spain, in order to identify appropriate mitigating actions.

### Methodology

Different variables were chosen and the influence of each variable is evaluated with respect to the severity of the accident. Since 2003 the Spanish National Institute of Safety and Hygiene at Works must be notified of all accidents that result an absence from work of one or more days. Notification must be sent through the electronic system called DELT@, filling in an official workplace incident notification form (Parte Oficial de Accidente de Trabajo). For this study, the Ministry of Labour and Immigration supplied the anonymised data of all workplace accidents in the Spanish agriculture sector, as defined by the National Classification of Economic Activities in Spain (CNAE 93.Rev 1) for the period 2009-2012. Contingency tables were made and chi-square values were calculated to test hypotheses of the independence of each variable with respect to severity. In a preliminary approach we analysed all variables included in the accident notification form (57 variables), elaborating contingency tables. Variables whose majority of the values in their contingency tables did not reach a statistical significance were rejected for this paper. Finally, we chose the statistically better variables. The statistical analysis package SPSS (Statistical Package for the Social Sciences) was used to analyse the data.

## Results

Results showed that the severity of accidents was related to variables including: age; CNAE (National Classification of Economic Activities) code; size of company; length of service; place of accident; location of accident; day of the week; days of absence; deviation; injury; and climatic zones.

## Study limitations

Data analysed are only from Spain, so the conclusions may be different to other countries with other working conditions, but they can give some indications of sensitive common variables.

## Conclusions

Identification of the main variables present in agriculture accidents is an important step in order to minimise and reduce accidents and their consequences. The conclusions of current research can be used by agricultural companies in their occupational safety strategies and safety training programmes. Specific training can be designed taking account of specific needs for each group of workers and for each type of company. Different training strategies should be investigated and developed in order to improve the effectiveness of training in agricultural workers. New safety procedures and measures must be implemented. The authors encourage further research on the issue and promote future solutions to prevent and minimise the severity and the consequences of the risks involved.

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## 4. Injuries in the fishery vessels in Denmark

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### Background

Fishery is recognised as a dangerous work occupation with increased rates of accidents and injuries compared with land-based work. Statistics from the Danish Maritime Authority have shown a decline in the number of injuries among Danish fishermen in the period 1998-2012. The decline may partly be explained by structural changes in the trade, i.e. changes in legislation and regulation, but also, most likely, by changes in the requirements of training for fishermen, the introduction of more effective technological aids, and also by changes in the safety culture among Danish fishermen, which has led to an increased focus on safety. The aim of this study is to investigate the development of reported injuries in commercial fishery in Denmark. Furthermore, this study aims to depict important characteristics of the reported injuries to get a better understanding of which areas of Danish fisheries need attention to reduce further the number of occupational injuries in Danish commercial fishery.

### Data

In this study we use data from the Danish Maritime Authority to investigate the development of reported occupational injuries. From 1998 to 2012, 2013 injuries were reported to the Danish Maritime Authority, with information about age, ships, type of injuries, time of day, seniority, and expected sick leave. Excluding 272 injuries that did not result in absence from work for more than 24 hours, and 206 with missing information, a total of 1741 injuries was left for further analyses.

### Methods

Data was analysed in simple descriptive analyses to document the development and to indicate special characteristics of the injuries and trends in changes. To compare changes over time, incidence rates were calculated.

## Preliminary results

The number of fatal injuries and serious injuries decreased during the study period. The most commonly reported injuries were caused by slips and falls, and squeezed fingers or other body parts. Incidence rates were elevated for young employees and, additionally, the number of accidents was shown to be significantly higher in the first year of employment compared with the following years. The length of absence from work due to the injury was shown to increase with age. These patterns remained over the entire study period, indicating a persisting need for special attention to reduce the risk of injuries among young fishermen. The study may have a number of practical implications, but, particularly, the increased awareness of the possibilities in reducing injuries in Danish fishery even further could be an important consequence of this study.

*Keywords: Fishery, occupational injuries*

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## 5. Implementation of OSH controls and accident occurrence among farmers following completion of a risk assessment document

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### Topic

In Ireland, new safety, health and welfare at work legislation, introduced in 2005, permits workplaces, including farms employing three or fewer persons, to complete a risk assessment document (RAD) in association with a sector-specific statutory code of practice (COP). A RAD was developed, and training on its use was provided, for about 4,000 farmers on a pilot basis as part of a national prevention initiative. The RAD and an accompanying COP was circulated to farmers in 2006 (McNamara et al, 2014).

Murphy (2003) described the 'farm safety paradox', where farmers have the necessary knowledge related to farm occupational safety and health (OSH) but do not implement OSH controls. Stave (2005) suggested that providing OSH knowledge in a user-friendly format, which can be readily implemented, would assist with resolving the farm safety paradox. This paper, firstly, provides knowledge related to the level of implementation of OSH controls by farmers, following completion of the RAD. Secondly, it investigates accident occurrence with or without completion and with or without participation in training, using a national sample of farmers. Accordingly, it provides knowledge to inform on strategies for resolution of the 'farm safety paradox' among farmers.

### Methods

Two distinct research methods were used in this research as follows: (1) farm audits of OHS standards and practices were conducted; and (2) a national survey of farm accident occurrence was undertaken.

Regarding farm audits undertaken, 94 farmers agreed to participate in a voluntary audit visit, three to six months after completion of the RAD, to assess implementation of farm occupational safety and health (OSH) controls. The audit visit considered both implementations of controls that farmers had specified



in the RAD, and overall farm OSH standards. Farms were selected randomly, but purposefully, based on information available from the RAD related to farmer and farm-enterprise variables. The audit visits were conducted jointly by two persons qualified and experienced in farm OSH management.

The national survey on farm accidents was conducted among 891 farmers, who were representative of the national farming population by farm system and size above two hectares. The survey questioned farmers on the level of farm accident occurrence for the period from 2006 to 2011, and asked if the RAD had been completed or associated training undertaken. To determine the risk factors for farm accident occurrence, bivariate cross-tabulation of data with associated statistical testing provided results for association between independent variables and the dependent variable of farm accident occurrence to the farm operator. The results of the cross-tabulations then allowed selection of variables, which were statistically significantly associated (or within  $p < 0.1$ ) for inclusion in regression analysis. Variables, and those that were significant in bivariate analysis, were included in multivariate regression analysis.

## Results

The farm audits found that the 65% of farmers audited had an overall satisfactory OHS standard score. A higher proportion of farmers (92.1% versus 56.5%), who implemented the controls they specified in the RAD, had satisfactory farm OSH standards ( $p < 0.001$ ). Lower satisfactory OSH scores were associated with the following variables: high use of work time ( $p = 0.001$ ); farmer age ( $p = 0.029$ ) with farmers in the 45-55 age category having lower scores; and farm enterprise ( $p = 0.011$ ) with the dairy farmers having lower scores. Implementation of controls was not statistically associated with the standard of RAD completion, RAD training attendance, number of controls specified in the RAD, farm enterprise, or farm work-time input.

The national survey of farms found the prevalence of farm accidents reported among farm operators over the reporting period to be 7.2%. Among farmers surveyed, 62.9% reported completing the RAD, while 27.3% had attended a training course of half a day or longer, during which the RAD was explained. For RAD completion ( $p = 0.172$ ) and RAD training participation ( $p = 0.185$ ) variables, these were not statistically associated with farm-operator accident levels. For RAD completion, accident levels were similar, with 7% and 7.6% having an accident, respectively, while for RAD training-course participation, accident levels were higher at 9.1%, compared with 6.5% for non-attendance; however, farmers who attended training had larger-scale farms. Multivariate regression analysis indicated that farm accident occurrence for farm operators was statistically associated with farms where both operator and spouse had off-farm employment ( $p = 0.001$ ), and non-statistically among farms with above-median farm-labour input ( $p = 0.163$ ) and below-median levels of farm investment ( $p = 0.131$ ).

## Conclusions

The study findings based on farm audits indicate that having acceptable OSH standards is associated with implementation of controls specified in the RAD rather than its completion. The study-farm audit data also indicate that unsatisfactory OSH standards are associated with farms requiring high work time, dairying enterprise, and farmers in the 45-55 age cohorts.

The national survey of farm accidents indicates that farmers' completion of the RAD or participation in associated half-day training is not associated with farm accident levels. Farm accident levels were associated (non-statistically) with high farm-labour use and low investment.

Overall, the study data indicate a considerable level of OSH adoption among the majority of farmers. The RAD document and associated training provided utility among farmers who adopted controls, but alternative strategies are required where non-adoption of OSH controls occurs.



As both farm OSH standards and accident levels were associated with high use of farm work time, devising and implementing strategies to assist farmers to manage work time, and modify and develop farm facilities associated with lowering work time, is warranted.

Future training strategies, aimed at providing support for farmers to implement OSH standards, need to provide motivation to implement controls, particularly among those with inadequate OSH standards. As facilitated peer learning used in the form of farm discussion groups has been shown to increase the level of farm technology adoption in Ireland (Heanue and Hennessy, 2012), use of this methodology should be considered to increase farm OSH adoption.

*Keywords: Farm safety, health, risk assessment, training*

# Technical Session 14: Sector case studies: healthcare

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## 1. Risk assessment in a nuclear medicine department

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This study consists of carrying out a risk assessment, crucial for continuous improvement of quality and safety of any organisation. For this, tasks must be defined, hazards must be identified, and risks evaluated in relation to which workers are exposed, allowing a diagnosis of the condition of work, identification and/or quantification of risk, determination of the corrections to be made, and the prevention measures and most adequate protection required. For this study, the MARAT (Risk Assessment of Accident Method) was used. It was also intended to define the roles of the physician and the safety-at-work technician (TST), whose functions are both distinguishable and equally necessary.

In the nuclear medicine service, despite a high degree of specificity owing to exposure to ionizing radiation and consequent radiological risk, and the crucial role of the physician who is responsible for radiation protection, it is essential that the TST conducts a risk assessment in order to evaluate all the other physical, chemical, biological and ergonomic risks that exist in any health department. This should not be depreciated, despite the radiological risk being the predominant risk.

Although there is this predominant physical risk, for which responsibility for control passes mainly to the physician, there are countless other risks that could cause equally serious consequences. We highlight, for example: biological risks associated with any health service, which can have serious and incurable diseases as consequences; or ergonomic risks resulting from poor posture at work, lack of training, or the need for assistance for patients with loco-motor difficulties, which can lead to musculoskeletal injuries, among others. These, in turn, will inevitably cause not only physical but also social and economic damages. All these risks should be assessed and controlled, taking the necessary measures in order to prevent the occurrence of accidents or occupational diseases that are not necessarily less important than those resulting from excessive exposure to ionizing radiation or radioactive contamination. This is the field of action of the TST, which should not be devalued and has no less relevance compared to the work of the physician responsible for the department; they are simply different activity areas, which can and must coexist, and are of equal importance.

Checklists were developed for various activities and tasks, so that the level of risk and control of the situations studied could be analysed. The analysis allowed tasks to be determined that involve greater risk, and subsequent corrections to be made. The risks associated with exposure to ionizing radiation must be corrected with measures such as: the implementation of a radiation protection plan; written procedures for the organisation and execution of tasks; enhanced medical surveillance; and acquisition and provision of appropriate protection equipment. There are also ergonomic risks that can be improved/corrected with measures such as: increased medical surveillance; use of hands-free devices; implementation of written procedures for the organisation; and execution of tasks. There were still some biological and chemical hazards that required correction using some measures outlined above.

This study allowed the identification of risks associated with the hazards present in a nuclear medicine department, enabling appropriate prevention actions. For this, it was important to know the rules on the protection of the health of workers and the general public against the dangers arising from ionizing radiation (Directive 96/29/EURATOM).

The highest risk resides in activities involving contact with ionizing radiation, such as the handling and storage of radioactive substances, injection of radiopharmaceuticals, or acquisition of images in gamma-cameras. The limited health surveillance and the absence of a written radiation-protection plan increase the weighting of this type of risk.

This work enabled us to verify that the work of a TST in a department of this nature makes as much sense as in any other health department. Admittedly, the physicist is responsible for ensuring and guaranteeing the safety and effective application of radiation to obtain a diagnosis or prescription for the patient's therapeutic outcomes, but there is a whole range of risks that must be taken into account and these are the scope of any intervention by a TST.

Finally, the aims of this work are: development of a risk assessment in a nuclear medicine department, and the demonstration of the importance of the work of a TST in this department.

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## **2. Patient safety in integrated care**

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**Trond Kongsvik, Tonje C Osmundsen – NTNU Social Research, Norway**

### **Introduction**

Integrated care has been a widely used prescription for improving the healthcare system in a number of countries (Kodner and Spreeuwenberg, 2002). Integrated care is seen as a remedy for a number of pertinent treatment issues, especially related to quality and efficiency, in a time when lifestyle-related diseases are on the rise, affecting increasing numbers of patients on a lifelong basis. Integration and coordination are seen as the glue that connects separate healthcare units, and enables them to achieve joint goals with a patient-centred perspective.

In Norway, the recent Coordination Reform (CR) aims to promote integrated care between different healthcare providers (Ministry of health and care services, 2005; Romøren *et al*, 2011). The reform emphasises two important changes: improved coordination between health-service levels; and increased decentralised treatment in the local municipalities, moving the patients out from specialised care earlier. This entails a need for better information and communication across chains of care because patients arrive at the primary-service level with more extensive care needs, and because an increasing number of patients have lifelong multi-morbidity, which demands a more complex chain of care over long periods of time.

### **Scope**

This paper aims to shed light on how patient safety is affected by integrated care and the Coordination Reform. Patient safety can be defined as: "the reduction of risk of unnecessary harm associated with healthcare to an acceptable minimum" (Runciman *et al*, 2009). The overall purpose of this paper is two-fold:

- to review literature on how patient safety can be affected by the establishment of integrated and decentralised care; and
- to describe patients' and healthcare providers' experiences regarding how the CR has influenced patient safety.

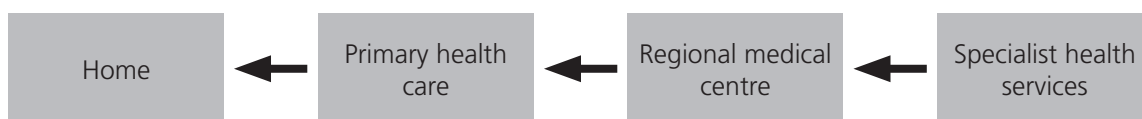
The empirical foundation of the paper will be approximately 20 qualitative interviews involving healthcare workers in different parts of the healthcare system, as well as patients and representatives of patient-interest groups. These interviews will be completed by March 2014.

### Theoretical foundation

In 2012, 14% of in-house patients in Norwegian hospitals were injured as a consequence of their treatment (Deilikås, 2013). These injuries can be regarded as accidents – or non-intended events that cause injuries to people, the environment or material assets.

Lack of information and breakdown in information flows are established perspectives used to explain accidents in complex enterprises, especially linked to Barry Turner's theory of 'Man-made disasters' (Turner and Pidgeon, 1997; Rosness *et al*, 2010). In this perspective, accidents are not regarded as isolated events, but as processes, developing from a normal state to an 'incubation period', where information is lost, misunderstood, simplified and distorted – eventually leading to a precipitating event. Accidents can be prevented by increasing information transparency and by establishing means for 'early warnings', e.g. indicators and safety audits, and also by promoting a good safety culture embracing all levels of the system.

Related to the scope of this paper, a goal of the CR is to make a shift in chains of care 'from right to left' in the treatment chain, illustrated in the figure below. This implies that more of the treatment should be given locally and close to the patient's home environments.



The paper will have a special focus on the information flow between the different actors. The coordination between them is dependent on the availability and quality of information, as well as comprehension of this information by the involved professionals. Thus, the interfaces between the actors in the figure are key. In the paper, we will explore if the CR has introduced new vulnerabilities in these interfaces that should be addressed, and define possible means to mitigate the patient-health risks in them.

So far, the CR has introduced a range of new procedures, routines and changes in patient pathways in both the primary- and specialised-healthcare services, and in the interface between these services. In addition, patients are discharged earlier from hospitals and arrive in the primary-health service with more complex needs. It also seems that for the primary-health service, the demand for increased knowledge has put a strain on professionals' existing training, and medical equipment new to the primary-care service creates a need for more training of personnel. On the other hand, the CR is also a driver for coordinated service, emphasising increased cooperation between professionals across the primary- and secondary-health services. The patient has also gained a more central role following the CR, and is receiving increased attention as a competent agent expected to be able and willing to influence his/her own pathway.

However, so far we know little of how these changes influence patient safety, something this paper will seek to remedy.

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## 3. Comprehensive guidance in the prevention of work-related upper-limb disorders in hand-intensive healthcare occupations: a combined scientific and practical approach

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### Background

Work-related upper-limb disorders (WRULDs) have been widely recognised as an occupational-health problem by the community of occupational health and safety practitioners and scientists. Known physical risk factors include repetitive movements with arms and fingers while applying force, awkward postures, and short work cycles. Practical guidance for the prevention of WRULDs mainly exists for computer work and repetitive manufacturing work.

WRULDs in healthcare occupations have not been widely addressed. One particular group of healthcare workers who warrant further attention are those whose work involves a high level of repetitive precision arm and finger motions while treating or handling clients ('hand-intensive occupations'), e.g. physiotherapists, massage therapists, dentists, and sonographers. These occupations are known to be at high risk of WRULDs. Application of industry standards and models for the prevention of WRULDs developed in industry may be limited.

The HITS (Health and Safety in Hand-Intensive Tasks) study was funded by IOSH and combined a practice-oriented approach with a scientific approach. The first objective was to conduct a systematic review of existing models of good practice for the prevention of WRULDs with a view to distil elements that could provide health and safety guidance. The second objective was to provide a scientific basis and determine work risk factors in typical hand-intensive occupations in healthcare.

## Methods

Objective 1: We systematically reviewed international models of good practice in relation to the prevention of WRULDs in healthcare, i.e. professional codes of practice, guidance documents and standards. The systematic searches were conducted on relevant international OSH websites in English, such as sites of regulatory agencies, professional bodies, government institutions, labour organisations, and OSH information sites. Documents eligible for inclusion in the review had to cover prevention of WRULDs applicable to hand-intensive tasks in healthcare. After identification of the relevant documents we conducted a systematic content analysis to summarise the main prevention criteria.

Objective 2: We conducted a questionnaire study with 347 employed and self-employed Irish therapists: 141 self-employed physical and sports/athletic therapists (response rate 76%); 135 chartered physiotherapists in private practice (response rate 54%); and 71 chartered physiotherapists in hospitals (response rate 31%). Their ages ranged from 23 to 72 years and included highly experienced therapists with more than 15 years of practice (28%) and career-starters with less than five years of practice (26%).

The postal questionnaire addressed: musculoskeletal symptoms; incapacitating symptoms; clinically diagnosed ULDs; physical, psychosocial and organisation work factors; injury-prevention practice; training; demographics; and lifestyle. Data analyses were adjusted for non-work-related explanations for ULDs, such as demographics, previous leisure-time injury, and lifestyle.

## Results

Systematic review: Internationally, there is no comprehensive guidance for the prevention of WRULDs among healthcare workers who perform hand-intensive tasks. The following elements for WRULD prevention were extracted: risk assessment and management of both physical work factors and organisational/psychosocial work issues; task-specific risk assessment; control over rest breaks; input into scheduling of clients; job rotation; variation of postures; injury-prevention training; health surveillance; self-care maintenance programmes; early and continued education; and involvement of designers and manufacturers of equipment.

Scientific evidence base: prevalence of upper-limb symptoms (neck, shoulder, hand, finger, thumb, elbows) was very high and significantly above the national average (more detail is provided in a separate presentation).

Work risk and protective factors:

- Input into scheduling of clients: Therapists who scheduled their own appointments were half as likely as those who used assistants or electronic bookings to report an upper-limb symptom.
- Predictable work, influence at work and social support: Therapists reported significantly fewer incapacitating symptoms if they had a high level of influence at work, a high level of predictability of work assignments, and high social support.
- High number of clients: Incapacitating upper-limb symptoms increased with the number of clients and were highest in the group who treated 11 or more clients each day. This was not due to increased hours of manual therapy with a high client load.
- Risk assessment: An alarming 76% of respondents had had no risk assessment of their work completed. Participants with risk assessment were significantly less likely for ULDs.
- Injury-prevention training: In total, 56% had received injury-prevention training. They were less likely to have experienced shoulder symptoms and were more likely to engage regularly in six out of the 13 listed good-practice strategies to reduce physical strain during work.
- Rest breaks: Therapists who took less than five minutes of rest time after each patient were more than twice as likely to have had incapacitating upper-limb symptoms than those taking breaks lasting five minutes or more.

## Conclusions

From our study results, combined with the results of the systematic review, we recommend the following elements for the development of a comprehensive guidance document:

A suitable scheduling procedure with adequate input from the therapist is paramount and may solve several problems. While applying the NIOSH recommendations on scheduling, different types of treatments each day should be scheduled to decrease continuous strain on specific muscle groups. Consideration should be given to the maximum number of scheduled examinations each day.

The ergonomics principles of job rotation, posture variation, and job diversification need to be translated into the task design of healthcare jobs. The same is true for job-decision latitude and control, which form important psychosocial aspects in the prevention of WRULDs.

Risk assessment of each specific task (i.e. the treatment of an individual patient) and modification of the treatment plan, as far as practicable, to prevent MSDs in the therapist are suggested. This requires some control over the planning of treatment plans.

The need for adequate rest breaks and micro pauses is apparent, especially in the context of repetitive manipulative therapy, and may be factored into the client scheduling procedures.

Health surveillance for MSDs may also prove useful to catch problems early.

Education at school level with specific reference to self-care and regular staff training in risk assessment and control measures, and in the use of low-strain manipulative techniques, is recommended.

*Keywords: Upper-limb disorders, prevention of musculoskeletal injury, occupational health*

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## 4. Analysis of the activity and work accidents in a university hospital

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### Introduction

The World Health Organization (WHO, 2003) estimates that the number of professionals exposed to the risk of percutaneous contamination varies between two and three million, and highlights the importance of information systems and analysis of accidents within this population. This proposal is also supported by knowledge concerning the potential severity, duration and cost of treatment in cases of biological contamination by viruses such as Human Immunodeficiency Virus (HIV), or hepatitis B or C (HBV and HCV), among others. This is a qualitative study design, conducted in a university hospital for the purpose of analysing activities and work accidents that expose health professionals to the risk of contamination by biological materials, and using descriptions of work revealed by Analysis of the Collective Work (ACT) targeting the best understanding of the network of multiple interacting factors identified in the origins of selected accidents.



## Methods

Nursing assistants and technicians were studied. The reasons for this choice were because they deal directly with patients, are the largest occupational category in health services, and have a history of high incidence of accidents. Analysis of the Collective Work (ACT) and Model of Analysis and Prevention of Accidents (MAPA) were used as two techniques of study. The ACT is a method of analysis of work in which meetings with small groups of workers, who are willing to talk about their work activities, are undertaken on a voluntary basis. This method uses the following guiding question: what do you do at work? The analysis of work is based on the speeches used by employees to describe what they do and how they do at work.

The MAPA adopts a systemic approach using concepts that seek to bring the understanding of the causal process of accidents, in order to overcome the proximal antecedents and exploit latent aspects located in managerial and organisational levels. The main steps of MAPA are: normal work analysis – for instance, without accidents; change analysis; barrier analysis; conceptual expansion of the analysis; concluding summary that emphasises contributions of production management, personnel, maintenance, etc; and prevention recommendations for accidents. Its use requires: observation of work with photographs and films; interviews with operators, colleagues and superiors; analysis of documents relating to all components of the sub-systems involved in the event; etc.

## Results

The ACT revealed that the routines of professionals were characterised by a list of tasks of patient care, comprising: switching shifts, cleaning, feeding, and administering medications. Tasks are marked by strict timetable requirements, aiming to ensure medical prescriptions, ongoing monitoring of vital signs, referrals for medical examinations, etc. It is observed that the prescribed work is very different from the real work because the activity is marked by great variability, interruptions and overlapping of tasks owing to urgent demands, such as declining health status of patients, sometimes to aid colleague in difficulties, etc.

The accident: A nursing assistant was hit by a splash of bodily fluids when she was moving a patient who had a serious risk of contamination to an isolated bed in the intensive-care unit. The analysis showed that moments before the work accident the nurse assistant had been severely criticised in public by her immediate boss and felt humiliated. At the time of the accident, she had to get help from that boss, which reactivated the memory of suffering reproach and feelings of stress. By moving the patient, a bubble ruptured and its contents splashed on the face and eyes of the professional. According to the worker, she did not realise the presence of bubbles on the patient's skin. The change analysis revealed that her usual co-worker for this activity was unavailable and the worker described feeling worried and anxious. The barrier analysis revealed that adherence to the use of personal protective equipment (PPE) was neither widely practised nor encouraged by the hierarchy. Security management had not identified a need for protection against splash during the handling and manoeuvring of patients. It had also failed to identify activities for prevention, such as the possible need for inspection of patients before performing shunting procedures. The normal work analysis helped the understanding of organisational aspects involved in the situation. The accident occurred on the weekend when staffing is reduced and there is an increased workload. Apparently, the rigid culture of the hierarchy makes it difficult for co-operation between colleagues during activities. This aspect, associated with momentary constraints and absences of colleagues, leads professionals to accelerate their *modus operandi* in a situation that is ripe for accidents, as verified in the case. The combination of technical analysis suggests that the working situation in the hospital, especially on the weekends, naturalises the performing tasks of the reduced teams with the workload that entails, and the workers have different strategies and acceleration practices of *modus operandi* that enable them to deal successfully with most of the various situations they face. The accident shows that despite all the strategies adopted, they are fragile and can be undermined by minor changes.

The study integrates thematic project research supported by FAPESP, and approved by the Ethics Committee of the Faculty of Public Health/SP and of the hospital.

*Keywords: Learning from research for practice, work accidents, biological material, analysis of the collective work, model of analysis and prevention of accidents*

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## 5. The emergence of design practices in healthcare: designing prevention in medical simulation

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This paper investigates the emergence of design practices between medical and non-medical professionals, and the role that such practices play in fundamental concepts of patient safety. It focuses on the early stages of planning as well as subsequent conducting of medical simulation sessions – where scenarios are designed for the improvement of patient safety. While medical professionals participate in medical simulation sessions for learning how to deal with safety-sensitive situations without putting real patients in danger, the design of scenarios requires the collaboration between medical and other professionals, such as engineers and psychologists, for developing together new understandings of patient safety.

Previous research at the intersection of design and patient safety (e.g. Department of Health, Design Council, 2003) has highlighted the need for medical work to be informed by design practices for improving existing anticipative and error-preventive approaches. In this vein, such research proposes the identification of design practices and methods developed in other safety-critical industries (e.g. aviation) and their transfer to healthcare systems.

Rather than approaching design and healthcare practices as distinct knowledge domains, this paper investigates how design practices emerge within settings of healthcare.

To do so, it explores:

- tensions between the creativity entailed in the design of scenarios and the use of preventive approaches to patient-safety improvements; and
- the emergence of new collaborative practices (Gherardi and Nicolini, 2000) in scenario design and the generation of new knowledge about patient safety.

Scenarios for medical simulation emerge through design that takes place in specialised centres and in real healthcare settings modified for holding in-situ simulation sessions. There, professionals from various disciplines take the role of instructors to set the basis for the design of scenarios. They do so by drawing on their long term-acquired experiences about safety and by envisioning situations in which incidents of risk, error and uncertainty are highlighted. But prior to the finalisation of any scenario they need to collectively unfold, negotiate and reconstitute fundamental notions of patient safety, such as error and prevention. Thus, scenario design provides the scope for inquiring how the methods and practices developed by instructors contribute to improvements of patient safety through the field of medical simulation. The paper identifies two leading questions:

- How does the envisioning of situations contribute to the development of instructors' practices for designing scenarios, and what kind of limitations does this create for new understandings of patient safety?
- What roles do the selection, modification and replication of healthcare settings play in scenario design, and what roles do specialised technologies for simulation play for the generation of new knowledge about patient safety?

Explorative aspects from both questions are addressed below:

1. A main part of the instructors' work is to translate their diverse and long term-acquired experiences about safety into concrete outcomes. In such work, the formation of the interdisciplinary team of instructors not only points to challenges of negotiating meanings of patient safety across medical and non-medical professionals, but also allows an exploration of how the instructors' work in identifying particular challenges and solutions creates the conditions for the development of common values and practices (Wenger, 1998).

In relation to the development of such practices, the paper explores the role that experiences play in learning about patient safety (Fenwick, 2003). Such experiences may provide instructors with occasions for individual reflections on their practices and also offer opportunities for developing collective reflective understandings of patient safety. However, the use of past experiences as a main source for scenario design raises concerns about their role in keeping real patients out of danger.

2. Training centres that provide facilities for medical simulation and special artefacts used in such settings play a particular role in the scenario design, since they invite instructors to draw on specific functions, excluding others but also inventing new ones. By studying the instructors' engagement with such settings, the paper addresses the role that technologies play in the transfer of instructors' knowledge in new simulation sessions.

For instance, while designing the role of a nurse, instructors need to imagine him/her as unable to attain some critical aspects of the patient's physical conditions, since the mannequins used in simulation have restricted technical functions. However, instructors often integrate seemingly mundane actions, such as verbal instructions, into scenario design to illustrate particular aspects of safety-sensitive situations.

The use of specialised technologies and the challenges they pose for instructors' practices set intriguing meeting points for studying aspects of the instructors' articulation work (Strauss 1988, Suchman 2007).

The paper reports ongoing empirical work and preliminary findings of the Danish Institute of Medical Simulation, based in Copenhagen, Denmark, and focuses on the development of instructors' practices while they design scenarios for educating medical professionals on patient safety. The study is informed by the ethnographic methods of participant observation, in-depth interviewing, and document analysis. Such choice enables this study to gain the insights of instructors on their experiences with notions of prevention, error and risk, while allowing the juxtaposition of such insights with the interactions that instructors have with the context in which simulation sessions are designed.

This study identifies with current research about the role of design methods and practices in new approaches for improving patient safety (Iedema, 2009), and reports how particular conceptions and practices directed toward the improvement of patient safety come into being. It addresses the interdisciplinary work for designing scenarios as a space for examining further relationships between design and patient safety. It contributes to practices of scenario design in medical simulation by: 1)

highlighting the implications that emerge for patient safety when experiences are used as a main source for designing new simulation scenarios; 2) showing that methods and practices of designing scenarios enable instructors to improve patient safety by re-thinking and re-establishing fundamental notions of patient safety; and 3) informing medical professionals on the role that design practices play in patient-safety improvements.

*Keywords: Design and healthcare practices, interdisciplinary collaboration, patient safety, envision of situations*

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## 6. Medical ethics: a tool to allay the tensions at the hospital?

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### Introduction

The current complexity of medical practice in a hospital environment – bound to the development of biotechnologies and therapeutic innovations, in a context of economic constraints and limitation of human, material and organisational resources – has created major difficulties in daily practices, situations of dehumanisation, and suffering for patients and healthcare professionals that run contrary to a hospital's mission.

The irreversible rise of computing in the management of information and medical-record data has created an additional problem concerning confidentiality and respect for professional privacy.

Can ethics, recently introduced in the medical field, constitute a tool to allay tensions in a hospital by calling for reflection on practices in discussions between all professionals about real-life difficult situations?

### Material and method

To understand the role that medical ethics could play, the committee members of ethics of the Inter Communal Hospital Centre carried out an investigation involving 1790 members of staff. The objective was, on the one hand, to understand the impact of confidentiality on the exercise of their work and the obstacles faced in respecting medical privacy and, on the other hand, to understand what each of them expected in relation to ethics and of the committee recently created.

## Results

In total, 322 answers were received in December 2012 and analysed in 2013.

Respect for medical and professional confidentiality appears to be an essential element for every professional. However, obstacles to its application are mentioned and grouped in several themes, which suggest many areas for improvement: behaviours; equipment and premises; organisation of the work; training; and management of computer systems.

Ethics constitute a real expectation but only a few professionals are ready to speak about it in their teams. This reflects the difficulties in raising a subject of a philosophic outlook.

On the other hand, support for reflection in a group or in teams of professionals around the practices, or around the particular and complex medical situations, concerning a patient is often mentioned.

## Conclusion

The difficult context of medical practice in a hospital today is one in which significant technical, scientific and computing developments, associated with major economic constraints, often lead to the 'disappearance' of the human being and the negligence of medicine's essential mission.

Medical ethics – by having a dedicated committee, through training, by promoting its values, and by being a topic for reflection and discussion among healthcare professionals – can be a tool to allay tensions at the hospital.

# Technical Session 15: Protecting vulnerable groups

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## 1. Statistics of accidents in the Portuguese elderly population: a short review

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**António Ribeiro** – ISLA Leiria, Portugal

The term 'ageing' is increasingly used in individual conversations, in public debates, and in statistical analyses in search of solutions for modern society. The Portuguese elderly are more than two million and represent nearly one-fifth of the resident population according to the latest national census (INE, 2011).

The term 'ageing' now appears to be associated with the expressions 'quality of life' and 'health of older', and implies the maintenance of physical, psychological and social autonomy, in which the elderly are integrated into secure societies and assume full citizenship. The word 'active' is not only linked to the ability to be physically active or to be part of the workforce, but it has an implicit participation and individual involvement in social, cultural, economic and spiritual issues (Ribeiro and Paúl, 2008).

This short review of accident statistics emerged from the need to characterise the loss ratio of the Portuguese population aged 65 or more years old, as part of a project that is being developed on national policies and risk management of the activities of the elderly population.

Given the current reality – specifically, the demographic evolution and status of active ageing policies, as well as accident prevention of the elderly – a national project is currently being developed that seeks systematic responses designed to improve accident risk management within the activities of the Portuguese elderly, and within the context of active ageing. This short review of accident statistics emerged from the need to characterise the loss ratio of the Portuguese population aged 65 years or older.

Since the statistical analysis of accident records is essential information and a support tool for risk management systems, the analysis of accident statistics to facilitate the clarification of the magnitude of accidents during the last five years was defined as a requirement. To achieve this, indicators related to parameters of recorded accident incidence and severity are analysed. We seek to understand the statistical records available to study the trend of developments during the period under review, as well as to substantiate correction and improvement actions.

This work (short review) took place using the following five steps:

- definition of the age group according to the World Health Organization and recognition of the number of elderly in Portugal (INE);
- identification of occupational activities with more participation, in particular, areas of work in the three economic sectors (agriculture fisheries, industry, and services), the actions of formal and informal participation in society (volunteering, non-formal care of people), household chores, sports and leisure, and actions for mobility and transport;
- search for information in the authorities, institutes and public offices, and academic work related to completed scientific articles from academic open repositories and online sites;
- overall assessment of accidents on the type, frequency and severity of injuries; and
- seeking an understanding of the evolution of accidents in recent years according to available data.

The third step of this work was dedicated to the search of information on accident statistics in public organisations and university courses developed in the areas of health, gerontology, social support, physical education, ergonomics, and OSH management, and in full papers available online in open academic repositories and sites.

Information was searched in the following organisations: National Statistical Institute (INE/ PORDATA); Authority for Working Conditions (ACT); Office of Strategy and Planning (GEP); National Institute of Health Dr Ricardo Jorge (INSA); and National Road Safety Authority (ANSR).

Given the subject and the fact that the desired data are framed by the national context, in order to perform online research of the articles and studies, various combinations of keywords were used while maintaining the word accident. The survey of academic work was guided by knowledge areas and access to open repositories of Portuguese universities and institutes – especially final coursework, dissertations and theses in the categories of health (geriatric and nursing), gerontology, social security, physical education, ergonomics, and occupational-risk prevention.

In total, 167 articles have been collected, but only two were selected in accordance with the requirements established. The majority of studies and papers were excluded. In these cases, although the descriptor contained one of the keywords, the sample either did not consider the Portuguese elderly or did not specify age group in the accident statistics (sociodemographic factor).

For the statistics of injuries due to accidents (work-related or not), among other information, the data on the injured person should be collected and recorded with the following elements: sex, age, occupation, and employment status (if applicable).

The registration of accidents or, more broadly, as in this case, work that seeks to understand the type and trend of the occurrences in all activities of the elderly has the following objectives:

- estimation of parameters on incidence, frequency and severity, or other applicable;
- understanding of the magnitude of accidents occurring in a given period of time; and
- analysis of the effectiveness of management's performance of OSH systems and policies in the study period.

Currently, in Portugal, the elderly number more than two million people, and they perform occupational activities as diverse as they desire. Individually, they have functional, psychological and social conditions that characterise them as a vulnerable group when exposed to risk, and this is reflected by the increasing incidence of accidents.

In Portugal, registration systems of existing statistical data are coordinated by public agencies, and oriented to respond to requests from European institutions – such as in the case of traffic accidents or regarding compliance with European Council directives within the context of the labour – and have been transposed into the national judicial system through several documents that regulate the legal regime of prevention and promotion of safety and health in the workplace. These platforms do not follow criteria for integration of multiple systems – for example, a traffic accident occurring on the way to work should not be considered and loaded into the database as a normal traffic accident, but rather as an on-the-job accident. In many areas, the information available regarding people aged 65 or over is sparse and, often, too specific to extrapolate to attain a realistic national picture.

Existing data are insufficient to establish a trend for frequency and severity rates of accidents, or to conduct a more detailed analysis of accident causation when the victims are elderly. These data would enable the identification of causes and contributing factors in the following three key areas:



- organisation, processes and procedures adopted by each type of activity;
- technological and technical means and products used; and
- the intrinsic and extrinsic characteristics of individuals within this age group (human factors).

In recognising the importance of human factors and of the age variable among injured persons when determining accident causality and proposed measures for accident reduction, it would seem appropriate to ponder the needs of this field in order to yield the appropriate information for eager researchers, professionals and the general public, with the ultimate goal of detecting changes in the degree of task and product risk and, simultaneously, substantiate the need for legislation and standardisation (risk management policies) of the activities in which the Portuguese elderly participate.

*Keywords: Ageing, elderly, accidents statistics, age group*

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## 2. What age-management strategies are employers using regarding the health and safety of their older workers?

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**Carolyn Drake, Roger Haslam – Loughborough University, UK**

This paper presents research being undertaken at Loughborough University to ascertain what age-management strategies employers are using to protect the health and safety of older workers in the workplace. The research examines the facilitators and barriers to the implementation of age-management strategies. It also examines how employers are intending to manage the situation for those workers who wish to continue working beyond the default retirement age, as well as those who are below the default retirement age but whose work demands exceed their reduced capabilities.

Putting this into context, the World Health Organization (2012) states that the world population is ageing rapidly. Life expectancy will carry on increasing compared with previous generations; however, this is also concurrent with low birth rates. In Europe, in 1985, 12.8% of the total population was over 65 years; in 2010, that figure had risen to 17.4%, and by 2060, it is expected to double (OSHA. europa.eu (2012)). In 2012, in the United Kingdom, 35% of the total population was over 50 years of age, and the projected figures are set to increase to 38% in 2021, and 41% in 2041 (ONS 2013). The challenge faced by European and national policies is how to adapt to an ageing population. Governments are looking at the pressure on state pensions and have announced increases in the default pension age and mandatory retirement age has been removed. This will have an impact on employers and how they manage their ageing worker population and home-work balance. Griffiths (1997) said that “merely trying to increase the number of older workers, without a corresponding examination of

the consequences of such actions for their health and productivity, would be foolhardy". Reviewing UK statistics for the last three years, the highest incidence rate of fatalities was in the over-65 age group, with the highest major-injury incident rate in the 60-to-64 age group. The HSE (2013) also notes there is a difference in sickness absence, with younger workers typically being absent more often, but older workers being absent for longer periods. The Eurobarometer Survey reported that many Europeans believe that conditions in their workplace may not allow them to continue working (OSHA.europa.eu (2012)).

The literature provides no consistent definition for classifications of 'ageing' or 'older' workers. Many researchers have chosen to use 50 years as a threshold as they believe it enables possibilities for preventative measures (Costa *et al*, 2011). Kooij *et al*, (2008) found five overall meanings of age: chronological age; functional age (changes in cognitive and physical abilities); psychosocial age (own and others' perception of age); organisational age (skill obsolescence and career plateau); and lifespan age (value placed on retirement leisure time).

Research indicates the older worker has much to offer, showing them to be reliable, with a wealth of knowledge gained over many years of experience. However, there is acknowledgement that as people get older they may start to see some age-related decline in certain capabilities (e.g. physical, such as vision, hearing, flexibility and strength; and cognitive, such as processing function). While it may be possible to compensate for some age-related declines, certain work factors may exacerbate ageing decline (e.g. shift work, work-schedule time pressure, specific environmental conditions, and working practices, etc). Kowalski-Trakofler *et al* (2005) argue that ageing is a continuous process, and thus it is desirable that work requirements adapt along with changing work abilities. OSHA Europe believes it is important to include the older worker (as the expert) when assessing and implementing changes to their jobs. There are tools available to help employers assess the abilities of their workers; for example, Ilmarinen *et al* (2005) describe the Work Ability Index, which employers can use to assess workers' current and future state, with respect to their work demands, health and resources. As Silverstein (2008) states, employers who do not assess and support the older worker may witness various impacts, such as increased injuries, and loss of productivity and quality.

Exploratory interviews undertaken as part of the Loughborough University research examined the current position of employers and the challenges they face with an ageing workforce. Some issues appear to be sector-specific; for example, one employer stated that they are dependent on an ageing workforce owing to younger employees not being interested in working in their particular sector. Other concerns highlighted revolve around employers' ability to capture the older worker's wealth of knowledge before they leave the workplace. Employers stated that they are carrying out task assessments; however, these are generally analysed according to the abilities of a typical worker. Some employers responded that capability declines are only assessed *ad hoc*, mainly once an individual has reported a problem.

Although employers stated they are doing their best to retain older workers and provide flexible and tailored interventions, it would appear that some are experiencing the 'healthy worker effect' (Kenny *et al*, 2008), whereby those workers with poorer health, etc., have tended to transfer to less-demanding jobs or have excluded themselves from the workforce. Reducing the hours of the older worker or redeploying them to less-demanding roles were also options considered by some employers. However, with the planned increases in default retirement age, employers are aware there may be insufficient opportunities available for redeployment and part-time work in the future. In summary, it would appear that many employers are dealing with ageing-workforce issues on a reactive basis, whereas it is argued that these problems are important enough that they need to be considered proactively.

*Keywords: Occupational health and safety, ag(e)ing and older worker*

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## 3. Comparison of occupational accident risks and underlying causes between temporary and non-temporary workers

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When a company takes on temporary workers or newcomers, are these people at a higher risk of having an accident, should extra safety measures apply, and, if so, what? A newcomer is a person who arrives new to a workplace and therefore lacks experience in that specific environment. A temporary worker does not have a fixed workplace. Newcomers and temporary workers might be young people who are also considered vulnerable. This paper explores answers through examining accidents and exposures in the Dutch population. There are 3000-plus detailed accident scenarios available on victims in the group 'temporary workers', from a database of 23,000 reported and investigated serious occupational accidents over the period 1998-2009. Only temporary workers, including interns, are chosen because newcomers in the accident population cannot be identified. In the temporary-worker accident population, estimates of exposures to 62 different hazards were based on the results of an exposure survey from 2011. By combining the average number of temporary-worker victims per hazard per year, with hours of exposure per hazard per year, for the same sub-population, it was possible to calculate the risk of having an accident per hour of exposure. The risk rates for non-temporary workers could be calculated in the same way. In this way, the accident risk rate per hour of temporary workers versus the rest of the population could be compared for the 62 hazards. The results indicate that the risks for temporary workers are much higher with some hazards, but in half the cases are less than 1.5 times higher. For example, the risk of 'contact with moving parts of a machine during clearing, releasing or

unblocking' is eight times higher for temporary workers, and is 16 times higher for 'fall from a mobile scaffold'. However, for 'fall on the same level' the risk rate is only 1.3 times higher, and for 'contact with falling objects during mechanical lifting (not cranes)', the risk rates are the same. This paper will explore the patterns of differences in underlying causes to evaluate whether there are consistent differences between temporary and other workers across the different hazards. Are there any clues as to why temporary workers may be more vulnerable to some hazards than others? Issues that will be explored include such things as competence, making mistakes, and awareness of dangers.

*This work was commissioned by the Safety Centre of the National Institute of Public Health & the Environment (RIVM), Netherlands.*

*Keywords: Risk analysis, temporary workers, competence*

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#### **4. Lack of knowledge or plenty of reasons? Reflections on the possibilities of using knowledge about safety among carpenter apprentices in Denmark**

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**Regine Grytnes** – Department of Occupational Medicine, Regional Hospital of West Jutland, Denmark

Based on ethnographic fieldwork among carpenter apprentices in Denmark, this paper explores the reasons why using knowledge about workplace safety is not a straightforward encounter. As already pointed out by safety researchers, the relationship between knowledge, attitudes and practice is not a straightforward one (Lund and Aarø, 2004) and the relation between rule violation and safety outcome are equally blurred seen from the individual point of view (Marian Iszzat-White, 2008). Knowledge about safety and using it in practice is inscribed in situated practices at school and in the workplace. Safety thus becomes something that the apprentices learn while performing a task, i.e. engaging in a venture where something is at stake. The analysis shows that for the apprentices, safety knowledge is variably tied to – but also loosened from – the knowledge about safety that they have learned as part of the educational scheme at the vocational college.

The analysis draws on the analytical differentiation between 1) knowledge about safety as an instrumental form of knowledge and 2) knowledge of how safety is done as an action-oriented form of knowledge. In relation to the empirical case presented, the second form of knowledge relates to the way that carpenter apprentices learn their craft – and how they learn to practise safety. Using safety knowledge is thus not about applying knowledge but rather an inherently bodily and experiential practice. While practising their craft, the apprentices establish a feeling of security, and a confidence that they can do the job. Using safety knowledge is thus not about remembering or applying knowledge about safety, but is rather an integrated and reasoned practice that establishes itself in reality. The paper offers a perspective on safety knowledge, as linked to the practice of managing potentially unpredictable situations in a heedful manner, and points towards new understandings of what using knowledge is about.

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## 5. Factors contributing to young workers' occupational injury risks in the Danish retail, healthcare and metal industries

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**Pete Kines** – National Research Centre for the Working Environment; **Mette Lykke Nielsen** – Aalborg University; **Johnny Dyreborg**, **Martha Ozmec** – National Research Centre for the Working Environment; **Kent Jacob Nielsen** – Herning Regional Hospital, Denmark

### Background

Current international studies show that young workers aged 18-24 years have a 40% greater risk of occupational injury compared with workers over the age of 24. Young workers are often treated as a homogeneous group, and workplace safety interventions are often solely targeted towards modifying attitudes and behaviours among young workers, with disregard for the type of work and the work context within which the young people work.

The retail, healthcare and metal industries employ and have relatively higher injury rates for young workers. The retail industry is particularly relevant as it provides many young workers with their first formal experience in the job market – with some starting work as early as age 13-15. The objective of this presentation is to provide and discuss results of a comparative study examining work-related injury-risk factors among young and older workers', and their attitudes and approaches towards safety in the Danish retail, healthcare and metal industries.

### Methods

A comparative study of young (aged 18-24) and older (age over 24) workers in 22 companies from the retail, healthcare (nurses' aides in elderly-care homes) and metal industries. The retail sector is generally known to have a mixed-gender workforce (in this study, 51% females, 49% males), whereas healthcare is dominated by females (in this study, 90% female), and the metal industry is dominated by males (in this study, 91% males). A mixed-methods design is applied with 66 semi-structured interviews, and with 1238 questionnaire respondents (274 of whom are aged 18-24). An independent samples Mann-Whitney U Tests is used to compare the questionnaire results of young and older respondents using a 95%-confidence interval level.

### Results

The overall injury rate in the three sectors reflects previous studies, with a 40% increased risk for young workers, yet is highest in retail (120% increased risk), followed by metal (36%) and healthcare (19%). Young workers in all three sectors take safety into consideration when beginning a task to a lesser degree than the older workers. When asked if and when they take chances at work even though there is a risk of injury, young workers, to a greater degree than older workers, say they do so because they can do their work better and faster, and not because they want to do something dangerous (risk-seeking) or to gain respect from colleagues. Young workers do not think of their work as being particularly hazardous, and risks are perceived as a normal part of their work. Taking chances is rather seen as a form of adapting and 'mastering' a task, and as part of a 'risk socialisation' process in the workplace.

Work outside 'normal' working hours (after 3pm and on weekends and holidays) is much more prevalent among young workers in retail (57%) than in the healthcare (38%) and metal (0%) sectors. Similarly, 60-70% of both customers and sales in the retail stores studied come after 3pm or on

weekends. In addition, the extent of general safety introductions (54%) and instruction in use of technical aids (60%) were lower among young workers in retail than young workers in the other two sectors (80-95%). Working and workplace conditions, as well as age segregation, are therefore often different for many young retail workers compared with older workers, which (in)directly may contribute to their increased risk of injury.

### **Conclusion**

For young workers, mastering of injury risks is often seen as part of the job rather than something to be avoided. The risk socialisation process, as well as factors in the workplace (safety introduction, instruction and follow-up) and working conditions, may contribute to young workers' increased risk of injury – particularly in the retail industry – and should be explored further in workplace injury-prevention strategies.

*Keywords: Risk socialisation, safety introduction, safety instruction*

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## **6. Violence against taxi drivers in Germany**

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**Claus Backhaus, Angelika Stadler, Christian Felten** – Statutory Accident Insurance Body for Transport and Traffic, Germany

### **Introduction**

Taxi drivers are often exposed to verbal and physical violence during their work.<sup>1</sup> So far, there is a lack of relevant studies on the situation of violence in the taxi branch in Germany. The present study provides a first quantification.

### **Method**

In total, 741 taxi drivers from different major cities in Germany were interviewed to find out the incidence of violence at work in the taxi branch.

### **Results**

The mean age of the subjects was 48.6 years with an average work experience of 13.5 years. 57.2% of the surveyed taxi drivers reported an experience of verbal assault, and 29.1% of physical assault. 79.3% of the physical assaults occurred at night. 84.6% experienced violence from a male attacker with an average age of 31.3 years. 34.8% of the taxi drivers described robbery as a motive for the attack, and 77.2% of the attackers acted under the influence of psychotropic substances. Xenophobic motives were denied by 81%. Half of the physical attacks started out as a verbal attack, but the escalation was unpredictable for the victims in 76.5% of all cases.

### **Discussion**

The results clearly show how urgent prevention measures are required in the taxi industry. Suitable measures should include the introduction of surveillance cameras in the vehicles and special de-escalation training for taxi drivers.

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<sup>1</sup> EU-OSHA. (2011): OSH in figures: occupational safety and health in the transport sector – an overview. Bilbao (Spain): European Agency for Safety and Health at Work.

# TECHNICAL SESSIONS TS16–TS18

Friday 03 October, 09.00–10.30

## Technical Session 16: Government and non-governmental regulation

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### 1. Construction Design and Management (CDM) Regulations 2015 update! Impact and opportunities of the potential changes

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Stephen Coppin – Rider Levett Bucknall UK Ltd, UK

The Construction Design and Management (CDM) Regulations are currently under consultation to be amended so as to be directly in line with the EU Directive 92/57/EEC on Temporary and Mobile Construction Sites, first published in 1992. After several reviews with ministers and lawyers, the Health and Safety Executive has now insisted it is on track to bring these changes to the CDM Regulations into law by April 2015. The current draft contains a total of 38 regulations within six parts, following a more linear structure than the existing legislation.

Focus is on the main changes between the existing and new, such as: the new role of ‘principal designer’ being responsible for the H&S coordination where the project has more than one contractor; the client having more responsibility; the notification threshold changing; and placing the client duties for domestic projects with the first appointee.

We also discuss the impact of the Approved Code of Practice (ACoP) being withdrawn and replaced by sets of guidance tailored to the needs of respective duty-holders, especially those operating on smaller sites, together with a main HSE Legal Series guidance document.

Emphasis will be on ensuring that good procurement and construction design risk management are applied to identify the potential risks and opportunities these changes place on the client and all the key duty-holders, particularly the new role of principal designer. Key will be appointing duty-holders early and ensuring relevant management arrangements are in place to plan, prepare and ensure a project works safely without risk to ill health, and addresses the safe-for-use and future lifecycle of that building, facility or structure.

Key topics:

- Revising the CDM Regulations – important changes, where the Regulations apply, and what happens if you don’t comply.
- Who is responsible for what and how this impacts on the client and other duty-holders.
- Understanding the difference between the pre-construction stage and project execution stage (construction phase), and who is responsible for what.
- Removal of the independent CDM coordinator role and placing design-phase health and safety coordination with a ‘principal designer’.



- Removal of the Appendix 4 and 5 Competence Assessment criteria, replaced by a duty on information, instruction, training and supervision.
- Placing construction phase coordination duties with the principal contractor.
- Full application of CDM Regulations to all projects with more than one contractor on site (including domestic projects).
- Placing client duties for domestic projects with the first appointee (architect or contractor).
- How these Regulations will apply in relation to a project that began before the changes came into force but is completed afterwards (transition or phasing-in period).

*Keywords: Procurement, clients, competence, coordination, principal designer, designer, principal contractor, contractors*

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## 2. How do public agencies frame governmental and non-governmental risk regulation in practice? National and supra-national risk-regulatory logics in the case of the Italian railway sector

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**Alessia Bianco Dolino** – University of Milan–Bicocca, Italy

Since the 1990s, risk-regulation studies have identified some general trends affecting the regulation of human activities in order to avoid, cope with, or handle the possible unwanted and negative outcomes of such activities (e.g. Majone, 1997). Examples of such trends are: the involvement of private organisations in risk regulation (e.g. Power, 2005; Aven, 2011), or the presence of regulating organisations with a specific technical-scientific orientation, which are outside of the political arena (e.g. Baldwin *et al*, 2012). As a result, a growing number of human activities have fostered complex networks of organisations – regulators and regulated organisations interacting at different levels of government – dedicated to risk regulation promoting hybrid forms of regulation, self-regulation and meta-regulation (e.g. Scheytt *et al*, 2006). However, the analysis of such trends remains, to a high degree, abstract: risk-regulation studies fail to look inside these general trends and examine phenomena such as meta-regulation or self-regulation in practice.

The purpose of this paper is to fill this gap by:

- examining the way in which regulators – organisations in charge of monitoring and/or regulating the possible adverse outcomes of such activities at different levels of government, but not involved in the core activity of the regulated domain – interpret and translate high-level risk-regulation legislative frameworks in their everyday activities; and
- understanding the regulator's point of view on the distribution of roles and responsibilities about risk regulation.

In order to understand how public agencies frame and balance governmental and non-governmental risk regulation, we developed a case-study research design. The case selection follows the trends identified by previous studies about risk regulation mentioned above. By pinpointing a case as close as possible to those trends, some of the concepts and ideas developed here could, in principle, be useful to understand a broad and increasing population of cases: the population of risk-regulatory networks. The case of the Italian railway sector has been selected.

An analysis of the Italian rail-transport legislative framework allows us to identify the regulating organisations this study focuses on: the European Railway Agency, at the European level of government, and the Italian National Safety Authority, at the Italian level of government. The institutional logics theoretical-analytical framework (e.g. Friedland and Alford, 1991; Thornton *et al*, 2012) guides the empirical analysis of:

- different types of documents produced by the two regulating organisations – around 3000 pages;
- 25 interviews conducted mainly with members of the identified organisations; and
- observation of everyday activities within each organisation for a total of three months.

The institutional logics theoretical-analytical framework, through identification of the risk-regulatory logics shaping and shaped by the identified organisations, allows us to grasp the way in which regulators share and balance their regulatory activity within the sector, as well as the differences between the European and Italian levels of governments in adjusting such a balance.

The analysis points out that:

- the European and Italian levels present two different prevailing logics: the cost-benefit logic prevalent within the European Railway Agency, and the standards logic prevalent within the Italian National Safety Authority; and
- the two logics represent different positions on the balance between governmental and non-governmental regulation. Both the logics leave the responsibility of risk decisions to the regulated organisations: technological risk is seen as a part of business risk. However, between them, they vary, posing different limits to the regulated organisations' decisions on risk acceptability. This is particularly relevant given the prospect of reaching a unified European railway market with a common safety approach.

The paper is structured in three main sections. In the first, the theoretical framework is presented: the main characteristics of today's risk-regulation network, which guide the case selection, are summarised, and the theoretical analytical framework of the institutional logics perspective is presented. The second section is dedicated to the research design: case selection, data collection, and data analysis. The third, addresses the case of the Italian railway sector. A brief reconstruction of the recent history of the Italian railway sector identifying the principal turning point in the post-EU legislative evolution of risk regulation constitutes the general background upon which the main empirical results are presented. First, the identified institutional logics – cost-benefit and standard logics – are described. Then, the approaches of the regulators regarding the balance between their roles and responsibilities and the ones of the sectors are detailed. In conclusion, we highlight the stimuli for reflection offered by the empirical analysis for both scholars and practitioners.

*Keywords: Risk-regulatory network, governmental and non-governmental risk regulation, risk-regulatory logics*

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### 3. A reflection on the current local authority-led regulation model: views from small and medium-sized businesses

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**Lisa Borley** – Peterborough City Council / Middlesex University; **Alan Page** – Middlesex University, UK

#### Background

Health and safety regulation has been identified by the UK government as an area of over-regulation, a burden to business, and a hindrance to economic growth. This view, was largely triggered by the Global Competitiveness Report of 2010/11 – which evidenced government regulation as a weakness and that inefficient government bureaucracy stifled business in the UK – ranking the UK 12th out of 139 countries in terms of its business competitiveness position. Of course, this view is inclusive of all regulation, including financial, but the government has focused heavily on occupational safety regulation as over-burdensome. At the same time, spending cuts have seen reductions of 28% to local-authority funding, which has forced a re-examination of how to deliver services, including health and safety regulation.

Recommendations have been made to government that action is taken to reduce regulation (Arculus, 2009; Young, 2010; Löftsted, 2011) in order to support business growth and aid economic recovery. While this seems to be the view held by government, many sources indicate that health and safety regulation has a role to play in supporting business (O’Neil, 2013; Vickers, 2003; Russell, 2012) and that ‘good regulation’ can actually help businesses and aid in their growth and economic prosperity.

Guidance issued by the HSE to local authorities has left local-authority regulatory departments unable to undertake proactive inspections in medium-risk and low-risk workplaces, relying instead on intelligence to trigger reactive investigative visits. Such visits effectively only allow the prevention of future repetitions of unsafe practice rather than preventing harm in the first place. While this may be an appropriate step for larger multi-site companies that manage OSH risks well, the evidence suggests that this is not the case for SMEs, presenting a risk of increased accidents and illnesses to the UK’s workforce and, ultimately, a cost-shift from businesses to the public purse (O’Neil, 2013).

#### Method

An empirical qualitative methodology was applied to test the health and safety compliance advice required by SMEs. Semi-structured interviews (n=10) were carried out with selected SME owners/managers across a range of sectors with varying exposures to health and safety regulatory interventions, in the City of Peterborough. The interviews were conducted face-to-face at the business premises, and recorded and transcribed. The data were coded in order to establish emerging themes that were used to develop theory.

## Results

Ten themes emerged from the data. The strongest themes that emerged were that businesses did not feel that deregulation or reduced inspections are a good thing. They wanted to continue to have inspections on a frequent basis. They felt that fewer inspections would lead to lower compliance levels and increased accidents. In addition, SMEs indicated that they do not have the skills or capacity to self-regulate and, thus, wish for tailored business advice to aid in protecting their workforce.

## Conclusion and recommendations

The presumption that regulatory visits are negative is questioned by the research and, indeed, all interviewees welcomed the support they gain from such visits. With this in mind, it is suggested that a more business advisory approach is adopted to meet SME needs and aid growth while still protecting the workforce. A number of recommendations are made, including a risk-based proactive intervention strategy based on responsive regulation principles, improvement of communication and business engagement, and focus on advice provision for SMEs. The recommendations are designed to meet businesses needs and also to contribute to business growth.

*Keywords: Business growth, business advice compliance, deregulation, health and safety, local authority, regulation, SMEs*

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## 4. The challenge of harmonising regulations

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**Anita Moen, Preben Lindøe – University of Stavanger, Norway**

In the aftermath of the Deep Horizon disaster in 2010, risk regulation in the offshore industry has gained increased attention, both nationally and internationally. In Norway, the regulatory regime is once again on the political agenda, driven by an EU initiative and the white paper, 'An industry for the future – Norway's petroleum activities' (OED, 2011). A main feature of the Norwegian petroleum industry is the use of functional requirements that outline goals and management responsibilities rather than detailed, prescriptive demands. Several evaluations and case studies support the internal control principle and involvement of stakeholders as a viable strategy (Lindøe, 2002; Bang and Thuestad, 2013).

Risk regulation is increasingly trans-national in nature, and regulation is conceived and implemented at different levels involving numerous 'translations', which raises important challenges. The overlapping risk regulation from various sectors and levels increase the complexity of risk management and, in the end, may threaten the robustness of the regime. One of the main challenges of risk regulation in a global context is the harmonising of internal safety (working environment) and external safety (environment and emissions). Both the 'internal regime' and the 'external regime' address safety issues, but from different angles and are based on different ideological, institutional and legal traditions. The challenging nature of regulating internal and external risk is exemplified by the proposal of new EU regulations regarding offshore safety and the reactions following this. Based on this, the paper addresses the discourses in the wake of the proposal and introduction of the new EU Directive on Safety of Offshore Oil and Gas Operations, building on the scholarly literature on risk regimes. Risk regulatory regimes are commonly conceptualised as relatively bounded systems with a certain degree of continuity over time (Hood, Rothstein *et al*, 2001; Lindøe, 2002; Barem *et al*, 2014). This point of view may be appropriate when analysing the regimes by addressing the composition of the Nordic model of tripartite involvement.

The initial proposal of the new EU regulations fuelled a public debate in Norway about the consequences of implementing the proposed EU regulation, involving actors ranging from the

Ministry of Petroleum and Energy, stakeholders of the industry, enforcement agencies (the Petroleum Safety Authority, PSA), unions, and non-governmental organisations (NGOs). The public debate and decision-making processes in the wake of the initial proposal indicates that the relationship between the regime of internal safety regulations and external environmental regulations are complex and multi-dimensional. The former oil and gas minister in Norway, Ola Morten Boe, has indicated that the directive is not relevant for Norway, while environmental body Bellona believes that the directive falls under the European Economic Area (EEA) agreement. It is, however, beyond the scope of this paper to consider whether Norway is bound by international agreements (EEA) to implement this directive, but the discussion directs the attention towards the challenging task of harmonising regimes (internal environment safety and external) with different regulatory approaches and, to various degrees, objectives. The regimes are founded on different historical, institutional and legal structures and, to some extent, the regulations are enforced by different regulatory bodies and correspondingly different enforcement strategies. The public debate illustrates that the interfaces between these regimes are complex and unclear.

The paper is based on a qualitative textual analysis of a strategic sample of official documents, such as research reports, reports, public hearings, pamphlets and newspaper articles, addressing the debate. Texts can contribute to increased knowledge about complex social phenomena characterised by ambiguity (Law, 2004), and, based on these documents, we look into the process of harmonising internal and external safety.

We conclude that the regulatory traditions and the control-freedom component are central factors in the process of harmonising regulations between different regimes. In the Norwegian context, the tripartite model plays a fundamental role, and different traditions for involvement of stakeholders affect the degree of success of harmonising.

Nevertheless, some are critical toward such a regime and call for a harmonisation toward regimes that are composed differently. Hence, challenges of safety regulation arise in the interface between different regulatory regimes.

*Keywords: Risk regulation, offshore safety, harmonisation*

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## 5. Power relations and inspection strategies: a case study from the Norwegian offshore industry

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Ole Andreas Engen, Preben Lindøe, Kåre Hansen – University of Stavanger / IRIS, Norway

Recent studies of offshore oil and gas industry highlight problems relating to the supervisory role with respect to audit functions, the legal basis of the supervisory bodies, and the role-conflicts that arise when handling a function-based regulatory regime (Lindøe, Baram and Renn, 2014; Engen *et al*, 2013). This paper addresses how shifting power relations between the PSA (Norwegian Petroleum Safety Agency) and the industrial actors will affect the applicability of the regime and the inspection strategies. Based on empirical evidence we will discuss how 'politicisation' disturbs the power of balance between the regulator and the regulated, and how it affects risk and vulnerability of the Norwegian petroleum regime. The analysis will be based on interview data and document analysis from previous and ongoing projects.

Maintaining authority through governmental actors, such as the PSA, implies exercising legitimate power through legally binding rules and following up with sanctions. Strong governmental agents can exercise power by requiring companies and suppliers to comply with legal standards. In the Norwegian safety regime there has traditionally been a balance of power and trust. The way this is achieved has great significance for how risk is managed, how robustness is maintained, and how development and change may occur. The function-based regulations give greater leeway than detailed and prescriptive rules and procedures. By 'greater leeway' we mean that both companies and the PSA have been given autonomy to decide how they will handle the HSE field compared with the action potential that prescriptive regulations could provide. But the regime rests on the assumption that the involved parties have a common interest in that the system is maintained, and that the conflicts of interest that may arise naturally will be solved, without threatening the foundation of trust between the involved parties. Over the last 10-15 years we have seen several examples where the parties have used their power base in a way that has reduced their trust in each other, and, in some cases, this has turned into distrust and blocking of cooperation (Rosness and Forseth, 2014).

The autonomy created by the function-based regime is financially advantageous for the employers. It has an intrinsic value to the employer side because they can decide the choice of means by themselves instead of being overruled by the authorities. Similarly, the employees have a vested interest in the regime because it gives them relatively large influence, at least formally. This is provided through the formal arenas for collaboration. The Norwegian regulatory regime has thus given unions more power than other regulatory regimes would provide. The various groups' use of power to protect their (special) interests in the HSE field represents a type of politics that can be a challenge for the regime, particularly in its robustness. This is especially true in cases where special interest groups have large impact and create decision situations where more reason-based solutions are excluded. Such 'politicisation' is problematic because decisions are made on the basis of 'random' policy and encourage intervention without clear theoretical or normative grounds, such as risk analysis, ALARP principles, and cost-benefit analysis.

*Keywords: Inspection strategies, function-based regulations, power, politicisation*

# Technical Session 17: New technology

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## 1. Risk observatory of the German Social Accident Insurance – a strategic view into the near future

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Eva Flaspöler, Angelika Hauke, Ruth Klüser, Ina Neitzner, Fritz Bindzius, Peter Paszkiewicz, Dietmar Reinert, Gerald Wanka – Deutsche Gesetzliche Unfallversicherung (DGUV), Germany

### Background

The search for appropriate prevention measures often does not start until occupational safety and health (OSH) risks are obvious and accidents or diseases occur. But the working environment has fundamentally changed: it has become much more complex and it is in a flux driven by new developments from technology, society, ecology, economy and politics. Trend-setting developments, such as globalisation, high-tech or nanotechnologies, demographic change, precarious working conditions, the intensification of work, physical or mental violence, increasingly unhealthy lifestyles, and many other factors, severely influence workplaces and the working environment. They impose many new demands on employees and they change structures and processes, as well as methods and habits. All this calls for a new type of prevention that is modern and proactive. The underlying motto can shortly be described as “acting instead of reacting”.

### Aim

Proactive prevention intends to discover trends with a significant relevance to workplaces and associated risks as early as possible, to be able to schedule prevention resources in anticipation. Additionally, proactive prevention accounts for the individual and specific requirements of the target groups. In the German context, these are the various German social accident-insurance institutions with their different sectors and branches. For this purpose, the umbrella organisation the German Social Accident Insurance (DGUV) has developed two planning tools: ‘trend scouting’ and the ‘risk observatory (RIBEO UV)’. The synergy of both can provide a holistic concept for proactive prevention activities.

### Activities

In the context of trend scouting, experts from all areas of the DGUV and associated institutions report early signals of new trends to a working group consisting of prevention specialists. At this stage it is not essential whether these developments bear more chances than risks for occupational safety and health. In fact, the basic idea is to describe the potential future of work as accurately and comprehensively as possible. The identified trends are assessed and prioritised. If there is urgent need for action, DGUV takes the necessary steps immediately. This approach is meant to respond to short-term prevention needs of an overriding nature that are of interest to a majority of accident insurers. Examples of trends recently identified that call for such immediate action are: the upcoming spread of 3D-printers; the inclusion of children with handicaps in schools; and the growing use of ambient intelligence and wearable computing.

The second instrument, the risk observatory, RIBEO UV, is more geared towards the individual concerns of the various German social accident-insurance institutions. RIBEO UV leans on a broad range of trends identified at European and national level. The results of the above-described trend scouting are also used to update this catalogue of potentially risk-prone trends. RIBEO UV generates three main outcomes: 1. it identifies for each accident insurer, and their specific sectors and branches, those trends



that will particularly affect safety and health at work of their insured persons for the next five years; 2. it analyses the OSH risks (i.e. diseases, accidents, strains, exposures) related to these trends; and 3. it suggests tailor-made prevention measures ranging from communication approaches to regulatory action, to research projects. Thus, each and every accident insurer is provided with an individual set of information that enables them to take early preventive action and provide for the necessary resources. A comparison of the top trends identified for different accident insurers, and their specific sectors and branches, also reveals overlaps and starting points for networking, interaction and communication. It thus helps to set priorities when it comes to decide on costly prevention measures, such as research or communication campaigns. This look into the near future of prevention is only possible with the input from the workplace inspectors: RIBEO UV feeds on their knowledge and know-how via an internet-based survey. RIBEO UV was developed and is run by the Institute for Occupational Safety and Health of the DGUV (IFA).

The presentation will describe the DGUV instruments 'trend scouting' and 'risk observatory' in greater detail, and it will highlight initial results.

*Keywords: Emerging risks, risk observatory, trend scouting, proactive prevention, occupational safety and health*

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## 2. Application of ICT to smart personal protective equipment for safety management in the working environment

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**Grzegorz Owczarek, Agnieszka Kurczewska, Grzegorz Gralewicz** – Central Institute for Labour Protection – National Research Institute (CIOP-PIB), Poland

### Background

This paper provides an overview of the results of three projects related to application of the information and communication technologies (ICT) to smart personal protective equipment (PPE) for occupational safety and health management. Development and application of smart PPE includes integration of sensors, actuators, data transmission and processing units, as well as power sources within the PPE elements.

The introduction of ICT to PPE solutions is one of the priorities of several international safety and health organisations. The Central Institute for Labour Protection – National Research Institute (CIOP-PIB) also works on multiple research projects in this field. In this paper, the examples and the results of the selected projects, oriented towards the application of ICT to smart PPE for safety management in the working environment, are presented.

### Novelty

Development of the information support system for welders, based on augmented reality (AR) integrated with eye-protection devices, and new methods to identify and monitor the time of use of PPE equipped with RFID tags, as well as to monitor selected physical parameters of undergarment microclimate for identification of users' thermal comfort.

### Methods and findings

The main objective of the information support system for welders is to develop a model of AR system that allows additional pictures and/or security signs to be put in the field of view of welders using helmets with automatic welding filters. The pictures or signs can be useful to familiarise workers

with: welding place, area around the welding place, and potential risks. The model of AR system for welders takes advantage of: micro-camera recording of the area around the user, in order to identify the surrounding objects; AR displays integrated with welding helmets; electronic devices allowing for the communication between the camera and the display; sensor module (e.g. electromagnetic field, temperature of welded objects, etc.); 'defectoscopy' module (for non-destructive testing of welded objects); databases containing information about objects, manuals, etc.; and communication systems allowing for radio transmission of the information that can be displayed in the users' field of view. The AR system integrated within the welding helmets is programmed using the original software based on algorithms to identify defects arising during the welding process. Graphical user interface of the AR display provides the following information: actual intensity of welding current; temperature of welded object; actual shade number of automatic welding filter; welding technology (e.g. TIG or TAG); and information about potential hazards (e.g. magnetic fields, explosion, objects around welding place).

The concept of the RFID system is to identify and monitor the time of use of PPE equipped with RFID tags. PPE is characterised by a certain 'lifetime' associated with the loss of parameters, which depends on the degree of their exposure to environmental agents. Owing to the importance of this issue, it is reasonable to search for solutions on how to monitor the time of safe use of the PPE.

The system for measuring the undergarment temperature and relative humidity with data-logging and wireless data transmission consists of two main parts: a measuring module (temperature and relative humidity sensors with data-logger for measuring, data-logging and wireless transmission), and a carrier, integrated with underwear, for the measuring module. The designed system allows for viewing, analysis and wireless data transmission to the computer, personal digital assistant, or the server through GSM. The system is intended for tests with humans in real conditions.

*Keywords: Smart PPE, safety management, augmented reality, radio frequency identification, undergarment microclimate*

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### 3. Predicting firefighters' fitness for rescue operations based on machine learning and physiological parameters

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Firefighting is a high-risk profession and firefighters are exposed to a lot of hazards. Fire, explosions, high temperature, time pressure, and limited field of vision are some risks occurring in their daily work. In particular, an interior fire attack in a burning building can cause critical and life-threatening situations. Smart personal protective equipment (PPE) can assist in these situations by analysing, interpreting and visualising hazards through the processing of vital and/or environmental parameters. Physiological parameters, for example, can be used to show the health status of firefighters, and can therefore support decision-making in critical situations if analysed correctly and visualised clearly. The main challenge in this context is the correct interpretation of individual strain, which is closely linked to individual human attributes such as gender, age or physical fitness under extreme environmental conditions. Furthermore, there are no generally accepted physiological limits considering the high

physical demands during firefighting operations. The aim of this research was therefore to develop a classification model that enables conclusions about the individual state of health based on objective sensor data.

## Method

In realistic firefighting training, vital parameters of subjects such as heart rate, breathing rate, and core temperature were measured, together with corresponding demographic data of 21 firefighters. The subjects themselves rated their physical activity level with Borg's ratings of perceived exertion scale (RPE) during the training. Parallel to this, professional firefighter trainers, who accompanied the subjects, rated their strain using the same scale. The RPE scale is used to identify the level of felt exertion during an activity. The scale starts at 6 (no exertion) and goes up to 20 (maximum exertion). The physiological measurements, as well as the internal (self-assessment) and external ratings, were then used within a machine-learning context. With these data sets, different supervised learning models, such as support-vector machine, artificial neural networks, and decision trees, were tested in combination with greedy procedures to analyse their prediction accuracy.

The method for the generation of an algorithm for the prediction of firefighter strain consists of two steps. At first, an optimal separation between the two classes, 'high strain' and 'low strain', is computed using different machine-learning techniques. For the development of the machine-learning algorithms, the external ratings were used as class labels. Then, a function was computed to fit the separating hyperplane created by the classifier. In the second step, a 'score' is introduced, which is based on the distances between the particular data points and the approximated separating hyperplane.

## Results

Different algorithms were used to separate the two classes; the best results were achieved by neural networks and support-vector machines. Decision trees and Bayesian algorithms led to lower classification rates. Finally, the support-vector machine classification algorithm was chosen because of its easy-to-approximate hyperplane.

Different feature-selection methods were also used and compared: sequential forward/backward selection and combinations of these methods, as well as a Fisher feature selection and a PCA-based selection algorithm. Analyses revealed that feature-selection methods were superior in comparison to the PCA-like methods. Also, the use of more than three features did not lead to a further increase of the classification rate. Using three physiological parameters (heart rate, breathing rate, and core temperature) results in up to 84% of correct classifications. The use of only two parameters resulted in the following combinations:

- breathing rate, heart rate – accuracy: 72.7%;
- core temperature, heart rate – accuracy: 85.8%; and
- respiratory rate, core temperature – accuracy: 82.8%.

The results were computed using the approximated separating hyperplane. Therefore, the accuracy in the three-dimensional classification was reduced more because of the approximation than in the two-dimensional case. For this reason, the classification rate using three parameters is slightly lower than the best two-dimensional parameter combination.

## Conclusion

The results show a promising approach to subsume physiological parameters under one individual strain parameter (rate of exertion) and to visualise it. Thus, it is possible to identify high and low individual strain reliably using complex data. This can help in the use of health-monitoring smart personal protective equipment to increase safety, initially for firefighters, but conceivably for other fields of

application as well. Open questions are whether the identified algorithm is generally valid, how to cope with the existing analytical imprecision, as well as legal and behavioural aspects on which other BAuA projects are working on.

### **Acknowledgement**

*The project was carried out by HFC GmbH and initiated, accompanied and funded by BAuA.*

*Keywords: Stress and strain, physiological parameters, firefighters, machine learning, classification*

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## **4. Assessing the safety risk of a human/robot collaborative work cell**

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**Amira J Hamilton, Sarah Fletcher – Cranfield University, UK**

The ever-increasing demand to improve efficiency, raise production rates and reduce costs, while maintaining or improving quality, is driving the need for the automation of many manufacturing processes. Traditionally speaking, the default control measure for the risk management of automation in manufacturing has been the use of physical guards. The aim of this is to separate the human from the moving system in order to mitigate against the risk of injury as a result of collision.

Robot cell installations with physical guards can be difficult to deploy on some manufacturing assembly lines, especially when assembly items are very large or are not transported on a fixed track. The need for frequent access of the human operator on certain assembly lines precludes the use of physical guards, as it would disrupt production rates. Given that these physical safeguarding measures separate the human operator from the moving robot, the work performed by robots is effectively detached from that performed by human operators. This can be a limitation on some flow-lines where the human tasks cannot be completely separated from those of the robot. From a safety perspective, physical guards do not completely mitigate against the risk of injury due to a human trespassing the guarded area with the locks and interlocks engaged, or deliberately limiting their effectiveness through local process modifications.

Aerospace manufacturing processes typically involve a complex mixture of high- and low-skilled tasks, and therefore are a prime example of a system that cannot be completely automated. Hence, it is proposed that a collaborative human/robot work cell would allow the lesser-skilled manufacturing tasks to be allocated to a robot while the human operator carries out the more skilled tasks. This would, in effect, result in the design of a semi-automated flexible assembly line where the human and the robot work alongside each other and collaborate with each other within a pre-defined, shared and safeguarded workspace.

Work has been undertaken at Cranfield University to investigate the potential for using a collaborative robotic system in aerospace manufacturing. The aim of this research is to offer an example of a truly collaborative robot work cell that integrates readily available robotic systems with affordable, off-the-shelf, safety-rated, electro-sensitive protective equipment, which could be an inherently safer design.

The collaborative work cell that has been developed includes an overhead camera for topographical monitoring of the work area, as well as a ground-level scanner for horizontal monitoring. It also includes a bespoke facial-recognition system that allows only the authorised user to re-start the motion of the robot, in addition to a projection system, which flexibly marks out the safeguarded zones around the robot. Together, this assemblage of safety devices monitors the shared safeguarded workspace so that any violation of pre-set boundaries would initiate an immediate protective stop of the robot,

thus making the system inherently safer than traditional physical guards. This is because the protective equipment used is much more difficult to override than conventional gate interlock switches.

Additionally, the human/robot collaborative work cell has been developed to account for key human factors. As the level of automation in a system can impact on human situation awareness and mental workload, the collaborative system is being tested throughout development to ensure that system features – individually and collectively – do not impair operators’ experience or performance.

The safety case underpinning this work includes a risk assessment based on BS EN ISO 12100. The integrated system was subjected to a validation programme against a subset of requirements listed in BS EN 10218, in order to demonstrate that this is a practical and deployable solution. Trials have been carried out to demonstrate the efficiency of the integrated system. Human-factors trials have also been carried out to assess user experience and performance, given that it is crucial that we also maximise usability. The study combines traditional quantitative risk-analysis tools, such as fault-tree analysis and event-tree analysis. Alternative qualitative risk-analysis methodologies have also been assessed against this case study. Qualitative human-factors methodologies, such as hierarchical task analysis and subjective workload measurement, have also been utilised and presented.

*Keywords: Collaborative automation, safeguarding, risk assessment, industrial robot, electro-sensitive protective equipment, fault-tree analysis, event-tree analysis, hierarchical task analysis, aerospace manufacturing, human/robot cooperation, situation awareness, mental workload, BS EN ISO 12100, BS EN 10218*

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## 5. Using novel geographical information systems techniques to address regulatory challenges – from nuclear siting to regulation of major hazards and targeting inspection

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**Helen Balmforth, Joe Januszewski, Mary Trainor** – Health and Safety Laboratory, UK

Geographical Information Systems (GIS) techniques and data are transforming the way geographically based information can be collated and analysed to provide evidence to inform regulatory activities. The Health and Safety Laboratory (HSL) is at the forefront of these developments in the UK. This presentation begins with an overview of the fundamental GIS concepts and methodologies that underpin these developments. It then uses three case studies, drawing on applications for different regulators, to show how GIS applications and analyses developed by the HSL produce evidence that can be used to inform regulatory activities to meet a range of challenges.

Fundamental to the HSL’s approach to developing GIS applications and solutions is the identification of appropriate information, the linking and joining of disparate datasets, and the analysis and exploitation of the subsequent intelligence. The HSL’s Spatial Intelligence and Knowledge Analysis Team has developed data-matching algorithms and methodologies to create a number of datasets and solutions to address a range of issues. This has included the development of the National Population Database (NPD), which is a GIS-based tool to estimate population density distribution for a wide range of population types. The NPD includes residential, workplace, retail, leisure, tourism, and transport population estimates and also populations that may be more susceptible to harm, such as populations in schools, hospitals, care homes and nurseries. The HSL NPD is available UK-wide and in a range of

resolutions, including down to building-level detail. It is being used across government for a wide range of applications.

Using these tools and techniques, the HSL provides support and solutions across a wide range of regulatory areas. This includes the development of:

- demographic models and tools to aid the siting of new nuclear power stations on behalf of the Office of Nuclear Regulation (ONR);
- tools to identify the types and numbers of people exposed to risks from major-hazards sites to inform regulatory activity by the Health and Safety Executive (HSE) on societal risk; and
- tools to aid the targeting of risk-based regulatory inspection. This has been undertaken for a number of regulatory areas, including: i) for the HSE, where the 'Find-It' tool is now used to target workplace health and safety inspections on higher-risk premises and increase the efficiency of deployment of inspectors' time; ii) for the Department for the Environment, Food and Rural Affairs (DEFRA), where a prototype tool is being developed to help target agricultural inspection; and iii) for the Better Regulatory Delivery Office (BRDO), where the 'IRIS' tool has been developed to aid local-authority inspection across a number of regulatory areas, and is currently being trialled in Leicestershire.

#### **Disclaimer**

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*Keywords: Geographical information systems, GIS, risk-based inspection, major hazards, nuclear siting*

# Technical Session 18: Regulatory approaches: challenges and developments

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## 1. Translations of HSE culture: an intra-organisational, multi-level perspective

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Gudveig Gjørund, Trond Kongsvik, Kristin Mauseth Vikland – NTNU Social Research, Norway

The Petroleum Safety Authorities in Norway (PSA) included HSE culture as a concept in their framework regulations in 2001. Companies that fall within their jurisdiction should encourage a “sound health, safety and environment culture that includes all phases and activity areas...” (PSA, 2011). In order to support the companies’ efforts on the issue, the PSA has released guidelines, a brochure, and generally communicated their expectations to the industry on different meeting arenas.

In spite of these efforts, we will argue that the PSA’s conceptualisation of HSE culture is open and equivocal, partly because that culture is an abstraction in itself, but also because the PSA has based their descriptions on different theories on culture. According to Karlsen and Valen (2011) “...a paradox emerges, in that petroleum companies state that a sound HSE culture is vital, yet there are still differences in what they comprehend as defining and representing this state” (*ibid*: 2). This opens up the possibility for different translations, both between and within companies.

The purpose of this paper is threefold. Firstly, we will describe different translations of the HSE culture concept in different petroleum companies operating on the Norwegian Continental Shelf (NCS). The translations will be analysed according to three occupational communities, partly based on Schein (1996), upper-level management, middle-level management, and shop-floor personnel. In this paper we choose to call these communities the operator community, the engineering community, and the executive community. Secondly, we will discuss contextual conditions related to these communities, which can shed light on different translations of HSE culture. Thirdly, we will discuss the possible consequences of the differences, e.g. for organisational learning and practices.

This paper is mainly based on some of the empirical material collected in a project called ‘Translating HSE culture’, financed by the Norwegian Research Council. The empirical foundation for the paper is qualitative interviews in different petroleum companies operating on the NCS, complemented with information from relevant documents (investigations, laws and regulations, and guidance documents).

Theoretically, we will base our analysis on theoretical and empirical contributions on culture (e.g. Geertz, Keesing, Schein, Reason) and also on neo-institutional theory. Schein (1996) defines culture as “a set of basic tacit assumptions about how the world is and ought to be that a group of people share, and that determines their perceptions, thoughts, feelings and, to some degree, their overt behaviour”.

This definition corresponds with the concept of culture forming the different communities (operator, engineering and executive community), on which we are going to base this paper. We will supplement this way of conceptualising culture with some of the other theories on culture on which the PSA build their concept of HSE culture.



Regarding the neo-institutional perspective, one string of research considers what happens when organisational ideas meet organisations. Translation is a key concept that is used to illustrate this encounter (Røvik, 1998, 2007; Czarniawska and Joerges, 1996), and is described as a collective process, involving creation of meaning:

“The perceived attributes of an idea, the perceived characteristics of a problem, and the match between them, are all created, negotiated or imposed during the collective translation process.” (Czarniawska and Joerges, 1996:25).

The concept of HSE culture can be perceived in different ways and can also be seen as solving different problems, depending on occupational community belonging. This point will be elaborated, in light of our empirical material.

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## 2. Protecting workers through supply chains: lessons from case studies in two sectors

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David Walters – Cardiff University, UK

Case studies of the successful use of supply chains to support the effective management of health and safety on construction sites and in merchant shipping are analysed to identify factors supporting this success. The analysis reveals that a combination of external regulatory pressures and an industry structure that facilitates the establishment and implementation of good practice played a crucial role in the outcomes achieved. It is concluded therefore that while the findings lend weight to policy initiatives to utilise the power dynamics in supply chains to protect working conditions, they also suggest that surrounding institutional and industrial contexts exert a potentially crucial influence over their effectiveness. Consequently, it is further argued that such initiatives need to be responsively shaped to them. The implications of these findings for current approaches to regulating health and safety at work are discussed.

*Keywords: Regulations, supply chain, construction, shipping, effectiveness*

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### 3. Can and should organisations improve safety at work by influencing the lives of their employees outside work?

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**Ross Owen Phillips** – Institute of Transport Economics, Norway

Companies aiming to improve the safety performance of their employees often introduce changes at the organisational level by addressing policies and procedures, recruitment, training, job design, incentives, attitudes, or safety culture. In line with good practice, any change should account for the systemic influences on safety performance, such as management attitudes and behaviour, technical factors, or other environmental influences.

However, even when practice is good, the system considered is nearly always incomplete. In particular, the influence of non-work activities of employees on their safety performance at work is neglected. While this is understandable, given that organisations are ethically unwilling or unable to influence non-work factors, life outside work may have important influences on safety performance at work, and this may be especially pertinent for high-risk organisations.

To encourage discussion of this issue, we identify from the literature some ways in which employee activity outside work can influence safety performance at work. In particular, we consider how fitness for work is influenced by stress, fatigue, health behaviours and health outcomes, each of which can be influenced, to a large extent, by general life activities.

In considering solutions to these problems, we find that, contrary to assumptions, organisations may be able to legitimately influence life outside work in ways that are positive for employee wellbeing and safety in and out of work.

We provide the following examples of how this could be done:

1. By encouraging psychological detachment from work outside of work time, organisations may be able to reduce the effects of stress and associated health behaviours on fitness for work and safety performance.
2. Improved conditions at work may not only influence performance at work directly but also lead to life enrichment that enhances improved motivation and performance at work.
3. By consulting employees using measures such as participative schedule redesign and the use of scheduling software, organisations may be able to find schedule solutions that are optimal for individual employees, in terms both of their opportunities for sleep and other life activities.
4. Organisations that ask their employees to drive for work need to promote safe driving at work, but they may also legitimately promote safe driving to and from work, again enhancing safety behaviours while at work.

In addition to such measures, we also discuss the The WorkLife/Total Worker Health Initiative of the National Institute for Occupational Safety and Health in the US, which addresses the physical and organisational work environment concurrently with personal health decisions and behaviours of individual employees.

The potential benefits and drawbacks of integrative approaches to work health and safety are reviewed. We also address ethical considerations, and the extent to which individual employees and their unions would be willing to allow such considerations.

We conclude that there may be ways in which organisations can legitimately account for life outside work when considering systemic influences on safety performance at work.

*Keywords: Safety, work, driving, detachment, life enrichment, schedule*

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## 4. Defining low-hazard environments for common safety: common sense isn't it?

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**Colin Pilbeam, David Denyer, Noeleen Doherty, Ross Davidson – Cranfield School of Management, UK**

In this paper, we problematise (Alvesson and Sandberg, 2011) the binary classification of environments according to their inherent hazard. While classification has been fundamental to policy development (Young Report (2010) to the UK Government), such definitions are simplistic, underplaying the socially constructed nature of the underpinning measures and overlooking the importance of structural features of the environment. We challenge this classification and suggest four negative consequences. First, the prioritisation and extent of resource allocation for regulatory activities are reduced for low-hazard environments (Black and Baldwin, 2010). Second, working in environments designated as low-hazard may dull the perception of inherent risk and encourage risk-taking behaviour in employees. Third, managers acknowledge work environments are composite, being neither wholly high- nor low-hazard. A binary classification superimposed on heterogeneous work environments creates confusion, undermining effective safety decision-making. Finally, research, education and training may be directed away from low- to high-hazard environments because of perceived lower priority.

The definition of low hazard in the Young Report (2010) refers to “places where the risk of injury or death is minimal”, like shops and offices, where injuries are a result of slips and trips, lifting things, and repetitive strain. The definition drew on apparently objective measures of potential sources of harm, risk, frequency, consequence and sector. Many of these measures are socially constructed and we examine their implications. Additionally, important characteristics of organisational context overlooked in the earlier definition are considered.

Hazard is often defined as a potential source of harm or adverse effect, but these are hard to define and are open to misinterpretation. In many reporting standards, experiencing harm at work may not necessarily be related to a hazard unless there is an identifiable external event that causes the harm, e.g. a falling object striking someone. Cumulative exposures to hazards, which eventually cause harm (e.g. repetitive lifting), may not be classed and reported as ‘accidents’. Definitions often also draw attention only to physical injury, ignoring psychological injury. Organisational environments, such as service contexts, may not pose physical harm to employees but, nevertheless, may pose significant psychological harm, such as through stress, which is detrimental to health (WHO, 1948).

Risk is the likelihood that harm would result from exposure to a hazard. Risk is also not absolute, but influenced by context. ‘Inherent’ risks may be mitigated to produce ‘net’ risks (Black and Baldwin, 2012). For example, the competences of the exposed population or the control measures taken to

reduce the potential of exposure are important facets of context that transform 'inherent' risks into 'net' risks. Safety in some extremely hazardous environments has been defined as "a dynamic non-event" (Weick, 1987). It is dynamic because safety is preserved by timely human adjustments; it is a non-event because successful outcomes rarely call attention to themselves. These high-reliability organisations "almost never experience an operating failure of grievous consequences" (LaPorte and Consolini, 1991). Thus, risk is context-sensitive and of limited value in differentiating between high- and low-hazard environments.

The focus of the definition in the Young Report was on frequency of death and serious physical injury. However, frequency of incidents is misleading and fails to adequately differentiate between high- and low-hazard environments. For example, annual fatalities on the UK road network, deaths annually from medical errors in the UK, and the people who died in the 9/11 terrorist attacks are numerically similar (Buchanan and Denyer, 2012), yet roads, hospitals and office complexes would normally occupy different categories of hazard.

High-hazard environments may be defined by the magnitude of physical, psychological, or material consequences of an untoward event (Hannah *et al*, 2009). Definitions of high consequence involve "social loss, large-scale, unusually costly, unusually public, unusually unexpected, or some combination" (Vaughan, 1999). All of these terms, including "unusually", are open to multiple interpretations. Hazards can be labelled as high consequence because they are judged as such by those who are implicated, and by observers, particularly regulatory authorities and the media. In some environments operators and the public perceive the hazards to have such potentially grave consequences as to warrant their absolute avoidance (Roberts *et al*, 1994). Thus, the categorisation of environments as low- or high-hazard is not an objective decision but a subjective one supported by a legal framework geared to ensuring compliance.

In seeking to provide generic guidance, low-hazard environments are often characterised at a sector level, e.g. retail or education. This fails to account for variation below the sector level. Companies in the same sector differ in their safety performance, as do organisational units within the same company. This heterogeneity raises doubts about the utility of the comprehensive classification of sectors and organisations as low hazard. Moreover, this is even problematic within a single organisational unit, where a range of different yet inter-related activities may occur, some of which are more hazardous than others. Stock rooms typically have more incidents than shop floors.

The nature of organisational environments influences the level of hazard or risk. Interactively complex (Perrow, 1984; Zohar and Luria, 2003) environments are those where outcomes are unknown and potentially unexpected, where socio-technical systems are multifaceted with incompatible functions, and where information flow is indirect and ambiguous (Roberts, 1990a). Tightly coupled environments have 'time-dependent processes', 'invariant sequences of operations', 'the only way to reach the goal', and 'little slack' (Roberts, 1990b). Such interactively complex and tightly coupled systems have failure as an inherent property, because they will inevitably experience accidents that cannot be foreseen or prevented ('normal accidents' Perrow, 1984). High-hazard environments characterised by high velocity (Eisenhardt, 1989) may exhibit rapid and discontinuous change in demand, competition, technology and regulations. In high-velocity environments exacting tasks are performed under considerable time pressure, and decision-making processes are prone to heuristic reasoning processes and bias (Kahneman and Tversky, 1984). We propose that factors, including the degree of interactive complexity, organisational coupling, and velocity, may provide a better guide to the hazardousness of the organisational environment.

*Keywords: Risk, hazard, consequence, regulation, definition, Young report*

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## 5. The function of culture in written communications from the regulatory authority to the companies

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**Ragnar Rosness – SINTEF; Rolf Bye – Safetech; Fred Størseth – SINTEF; Jens Røyrvik – NTNU Social Research, Norway**

This paper discusses the possible implications of the use of the concept of 'culture' in written communications from regulatory authorities to companies. The research is based on an assumption that the concept of culture used in the communication may influence companies' safety policies, strategies and measures. The full paper describes how the different types of written communications (e.g. white papers, governmental information pamphlets, regulations and guidelines, accident investigations) define, treat and use culture in a variety of contexts.

We found that the concept of 'culture' varies between different types of documents with different functions (e.g. between accident investigations and governmental information pamphlets). Furthermore, the concept also varies over time within the same type of documents. Some of the documents that have been analysed even use different concepts of culture internally.

The document review shows that the concept of culture is used as an abstraction to denote a variety of organisational characteristics – a cause that may explain certain phenomena, and an effect of certain conditions. In some accident investigations, the concept of culture functions both as cause and effect in the causal explanations. Those conclusions might therefore be considered as tautological, and thus invalid as inference. The tautology is hidden though, as the usage of culture is in accordance with how the concept is explained by government documents, and the varied usage of culture in literature. As a result, the explanations, including culture as both cause and effect, are treated as valid, and no further investigations are therefore needed. The concept of culture used in this way, may therefore function as both black-boxing causality and, thus, the closing of investigations.

### Background and method

The concept of safety culture has been among the key topics within the community of safety studies for the last decades without contributing to any uniform definitions (Hale and Hovden, 1998). In this paper we are addressing how the concept of culture is used in communication from regulatory authorities to companies, based on documents developed by the Norwegian Petroleum Safety Authorities. This study is a part of the research project 'Translating HSE culture in the petroleum industry' (Tracult), which is designed to generate and disseminate knowledge on how regulatory authorities and companies can contribute to improving those aspects of HSE that are hard to explicate, measure and follow up. The empirical data in this study are documents related to the following regulatory documents produced by governmental bodies: 1) white papers; 2) information pamphlets; 3) regulations; 4) guidelines; and 5) accident investigations.

We have approached the empirical data by applying a semiotic perspective. This means that the word 'culture' has been analysed as a sign with respect to the use, functions and meaning within relevant documents. This analysis is based on the theoretical frameworks developed by, for example, Saussure (1974) and Peirce (1958). An important assumption for the analysis is to consider the relationship between signs (form) and the signified (meaning) as arbitrary, and that the sign has a polysemic quality in which meaning is constituted in relation to the use.

Methodically, the study is grounded in the hermeneutical tradition, and core analytical techniques inspired by critical discourse analysis (CDA). The hermeneutical tradition, the continual interpretation and reinterpretation of texts, would stress that: (1) texts contain underlying meanings; and that (2) they can be discovered by careful examinations of changes in meaning over time, and for different sub-groups of a society (Bernard 2006: 22-23). The search for meanings and their cultural interconnections requires a close and stringent examination of texts so that "the symbolic referents emerge during the study of those expressions" (*ibid*: 475), and techniques associated with CDA are appropriate in order to analyse investigations hermeneutically. These can be summarised by the following steps:

- *Defining the corpus of texts.* As Tracult is concerned with translations of §15 and the concept of 'a sound HSE culture', the documents were selected if they discuss §15, use §15, or were supposedly considered to include the paragraph but were omitted for one reason or another. Those documents that were referred to by informants were devoted extra attention, as it is of special interest to analyse documents that impact the understanding of HSE culture.
- *Identifying potential themes.* The research group consisted of four researchers, who first read the texts and extracted topics of interest individually, and who met regularly in order to compare and analyse those topics as a group. The documents were analysed with regard to how the concept of culture was used and what kind of function it had in each text. By comparing the different definitions and functions, the themes of interest for this study were pinpointed.
- *Analysing how categories are linked together.* In addition to comparing findings within documents, they were analysed as part of a contextual whole. Important contextual aspects in this regard include the history of investigations in the petroleum industry as well as the Norwegian political landscape. For this part of the analysis, other sources of information were of importance, such as the literature and interview study of Tracult (both focusing on HSE culture in the petroleum industry of Norway), research on public investigations, etc.
- *Articulating hypothesis.* The articulation of hypothesis has been a part of the analysing process from the start. Some were rejected, and others re-articulated, as the hermeneutic research process gave a more precise understanding of both the part and the whole.

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